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Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

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Abstract

Objective: Surgical complications may affect patients psychologically due to challenges such as prolonged recovery or long-lasting disability. Psychological distress could further delay patients' recovery as stress delays wound healing and compromises immunity. This review investigates whether surgical complications adversely affect patients' post-operative wellbeing and the duration of this impact.

Methods: The primary data sources were 'PsychINFO', 'Embase' and 'MEDLINE' through OvidSP (year 2000 to May 2012). The reference lists of eligible articles were also reviewed. Studies were eligible if they measured the association of surgical complications after cardiac, thoracic, gastro-intestinal or vascular surgery with adult patients' post-operative psychosocial wellbeing using validated tools or psychological assessment. 13,605 articles were identified. Two researchers independently extracted information from the included articles on study aims, participants' characteristics, study designs, surgical procedures, surgical complications, wellbeing outcomes and findings. The studies were synthesised qualitatively. Supplementary meta-analyses of the impact of surgical complications on patients' wellbeing were also conducted.

Results: 50 studies were included. Two thirds of the studies found that patients who suffered surgical complications had significantly lower levels of post-operative psychosocial wellbeing even after controlling for patients' pre-operative wellbeing, clinical and demographic factors. There were significant and clinically meaningful differences between patients with complications and patients without on aspects of quality of life including 'problems with daily activities due to emotional problems' (p<.01), 'interference with social activities due to physical and emotional problems' (p<.001), and 'feelings of nervousness and depression' (p<.001). Half of the studies with significant findings reported significant adverse effects of complications on patients' wellbeing at 12 months (or more) post-surgery.

Conclusions: Surgical complications are a significant independent predictor of patients' impaired post-operative psychosocial wellbeing and these effects may remain for a long time post-surgery. The results highlight the critical importance of attending to patients' psychological needs in the aftermath of complex surgery.

Strengths and weaknesses of this study

- This is, to our knowledge, the first systematic review of the literature assessing the impact of surgical complications on patients' psychosocial wellbeing.
- The validity of the findings is reinforced by the fact that only studies that used validated self-report measures for the assessment of patients' wellbeing were included in the review, as well as by the use of a very comprehensive search strategy for the identification of relevant literature.
- Caution should be taken when interpreting these findings to other specialties as the review was limited in four surgical specialties.
- A limitation of this review was the very small number of studies with sufficient data for quantitative synthesis, which did not also permit certain types of sensitivity analyses such as by surgical specialty or type of surgery.

Introduction

Surgical complications pose significant challenges for surgical patients. Complications may vary from very minor events that can be resolved relatively quickly without the need for pharmacological treatment or other intervention, to more serious events which can be life-threatening, require multiple interventions (e.g. return to theatre), delay patient's discharge and may lead to multi-organ failure or even death. [1] A recent review of the literature found that post-operative complications contribute to increased mortality, length of stay and an increased level of care at discharge. [2]

Other than the complications' impact on patients' post-operative recovery, they may also affect patients psychologically. They may contribute to the development of severe psychological distress such as depression or anxiety due to the challenges that are inherent to them in terms of prolonged recovery or long-lasting disability (e.g. severe post-operative pain, permanent disfigurement). An early study found that patients who experienced serious adverse events after surgery reported higher levels of distress than people who had experienced serious accidents or bereavements and psychosocial adjustment worse than in patients with serious medical conditions. [3] Moreover, the authors of an interview study on patients' experiences of cardio-thoracic surgery reported that a small number of patients who had a long and complicated post-operative hospital stay expressed intense feelings of hopelessness and depression. [4] Psychological distress resulting from the experience of surgical complications could further delay patients' recovery from surgery as increased levels of stress delay wound healing [5, 6] and compromise immunity. [7-9]

This review aims to critically review and synthesize the existing literature on the psychosocial impact of surgical complications on adult surgical patients and to estimate the types and duration of this impact. For this purpose, quantitative studies which assessed the association of surgical complications with adult patients' psycho-social wellbeing post-surgery were reviewed. Our hypothesis was that the occurrence of surgical complications adversely affects patients' psychosocial wellbeing. More specifically, the research questions that this systematic review aims to answer are:

- Do surgical complications impact on patients' psychosocial wellbeing?
- Is the psychosocial impact transitory or long-lasting?

Methods

Search strategy

The following databases were searched through OvidSP: 'PsychINFO' (1967 to 25th May 2012), 'Embase' (1947 to 25th May 2012) and 'Medline' (1948 to 25th May 2012). A search strategy was developed specific to each database. The three facets of the search strategy were:

A. Adult surgical patients

Terms such as patients, inpatients, outpatients, men, women were used for this facet.

B. Patient psychosocial outcomes

Key psychosocial outcomes that are commonly used to assess patients' wellbeing include anxiety, depression and quality of life. Terms for post-traumatic stress were also included due to the relevance of this psychological outcome in situations where a person is exposed to extreme stress. [10] Generic terms such as wellbeing and emotions were also used.

C. Surgical complications

Surgical complications were defined as any adverse event in relation to the surgical procedure including search terms for complications (e.g. adverse events, untoward incidents) and terms about the surgical setting (e.g. surgical, post-operative).

Each of the facets was expanded into a list of search terms truncated and combined with each other using Boolean operators, and also by mapping those to their relevant MeSH headings and sub-

headings in each database (through explosion of each MeSH heading). The search was restricted to titles and abstracts, and the results were limited to studies that used human participants and were written in English. The search strategies are presented as supplementary material. Database searching was complemented by reviewing the reference lists of eligible articles.

Eligibility criteria

Studies were included in the review if they met the following criteria:

- Any quantitative study that measured the association of surgical complications with adult patients' psychosocial wellbeing after surgery, either as a primary or secondary aim. Specific types of complications were not pre-defined as this review was interested in the impact of any surgical complications on patients' wellbeing. Psychosocial wellbeing was assessed with validated self-report tools or psychological assessment.
- Studies of surgical complications after cardiac, thoracic, gastro-intestinal or vascular surgery where complications are more likely to occur. [11] Studies of neuropsychological complications (e.g. delirium) and studies of transplantation procedures were excluded.

Conference proceedings, non-empirical data and articles that were published before the year 2000 or with the majority of their participants recruited before the year 2000 were excluded. This current approach in the selection of literature was expected to reduce bias resulting from studies of out-dated surgical practices.

Study selection

A total of 50% of the abstracts were reviewed independently by two researchers (AP and RD) and disagreements were resolved by consensus. The remaining half of the retrieved abstracts were

reviewed by the primary researcher (AP) based on the consensus that was achieved for the first half. After excluding ineligible articles at abstract and title level, the remaining articles were assessed in full text. The eligibility criteria were applied again on each article. Reasons for exclusion were coded. Articles for which there was uncertainty were discussed between the primary researcher (AP), a researcher with background in psychology (RD) and a researcher with background in surgery (AA). Any disagreements were resolved by consensus.

Data extraction and quality assessment

The primary researcher (AP) and a researcher with a background in surgery (AA) independently extracted data from 20 articles, which they reviewed for any disagreements. Disagreements were resolved by consensus or referral to a third senior researcher (OF). Data were extracted from the remaining articles by the primary researcher and were later checked by the second reviewer (AA). A total of 10 authors were contacted by email to provide information that was not included in the manuscript. Three articles were excluded from the analysis as their authors did not respond to our requests for further information. Information was extracted from each article on study aims, participants' characteristics, study design, surgical procedure, surgical complications (i.e. types, definitions and method of recording, where available), wellbeing outcomes (including scales and time-points of measurement) and relevant findings.

The quality of the included studies was assessed with the Newcastle Ottawa scales (NOS). [12] The scales were modified in order to reflect the research questions of the review and to also incorporate the assessment of cross-sectional studies.

Data synthesis

The included studies were first synthesised narratively. In order to quantify the degree of the impact of surgical complications on patients' wellbeing quantitative procedures were also used. A meta-analysis was conducted on each extracted wellbeing outcome using Review Manager (version 5.2).[13] I^2 was used to calculate the heterogeneity present in the meta-analyses. Heterogeneity was considered low when it was below 25% and high above 50%. [14] A random effects approach was chosen, as a degree of heterogeneity between studies should always be assumed in social sciences. [15] Where multiple assessments were conducted in one single study, only the one furthest from the participants' surgery was included in the meta-analysis.

Results

18,585 articles were retrieved in total across the three databases. After removing duplicate references, a total of 13,605 papers were reviewed at abstract and title level. 994 articles remained to be assessed in full text. A total of 51 articles (50 studies) were eligible for inclusion in the final stage of the review (see Figure 1).

-Figure 1 -

Study characteristics

Details of the included studies are presented in Tables 1-3. A total of 28 studies were conducted in Europe, 14 in the US, three in Australia, two in Turkey, one in Egypt, one in Japan, and one in Taiwan. There were 29 studies in gastro-intestinal, [16-44] 17 in cardio-thoracic, [45-62] and four in vascular surgery. [63-66] The majority of the included studies (40 studies) assessed major procedures. The most common indications for surgery were heart conditions, followed by different types of cancer.

Twenty-three studies examined the association between surgical complications and patients' wellbeing as a primary research aim. [17, 19, 28, 30-38, 43, 47, 48, 50-53, 55, 62, 64, 66] The remaining examined this relationship as part of an exploration of the association of different clinical factors with patients' postoperative wellbeing. The majority of the studies were cohort studies. There were four case-control and 20 cross-sectional studies.

Quality of life was the main psychosocial outcome. Three studies assessed anxiety,[30, 40, 62] four studies assessed depression,[31, 41, 49, 62] and one study assessed mood states.[41] No other psychosocial outcomes were studied. The SF-36 (and its associated versions, i.e. SF-12, SF-20) was the most commonly used scale for the assessment of quality of life.[18, 25-31, 36-38, 42, 43, 45, 46, 48, 51-55, 57-59, 61, 63]

The vast majority of the studies used a-priori definitions of complications. For example, Bloemen et al. recorded only severe complications based on a grading system of surgical operations. [19] Dasgupta et al., also recorded major complications which were defined as "those associated with systemic illness requiring transfer to a higher level of care or requiring relaparotomy, or complications needing interventional radiology". [23] Others used pre-defined categories of complications such as infections, respiratory complications, chronic postoperative pain or perioperative myocardial infarctions. A total of 14 studies did not define or describe the complications that were recorded. The majority of the studies recorded a range of post-operative complications. 18 studies focused on a single category of complications (e.g. anastomotic leaks, peri-operative myocardial infarctions, wound complications, atrial fibrillation). Complications were mostly recorded through medical records review, clinical examinations and review of administrative databases.

Study quality varied. The scores of the included studies ranged from 2 to 8, with a mean score of 5.9. Points were deducted for the following reasons: lack of information on how complications were defined or on the methods that were used for their recording,[16-18, 21-23, 25, 29, 35, 37, 40-42, 46, 51, 55-57, 61, 63] lack of information on response rates,[16, 21, 22, 25-27, 29, 37, 40, 50, 52, 54, 55, 57, 60, 61] patients' baseline wellbeing was not measured or controlled for in the analysis, [17, 19, 20, 25, 27, 30-36, 38-40, 43-45, 47, 49, 53, 63] and

demographic or clinical factors were not controlled for. [20, 25, 27, 31, 32, 34, 40, 43, 45, 51, 56, 61, 63] Only 7 studies scored exceptionally low (i.e. below 4).

-Tables 1,2,3-

The impact of surgical complications on patients' wellbeing

The majority of studies (n=32) found that patients who suffered surgical complications had significantly lower post-operative wellbeing than patients with uncomplicated recovery.[16-20, 22, 24, 25, 28, 30, 31, 33, 35-37, 39, 41-48, 50-52, 54, 57, 60, 62, 65] This was the case not only after major surgical procedures but also after relatively minor operations such as hernia repairs. [30, 18, 28, 31, 43] The vast majority (n=25, 78%,) were of high quality (i.e. quality assessment score greater than 6 out of 8). For instance, more than half of the studies with significant findings had measured and controlled for patients' baseline wellbeing (n=18) [16, 18, 22, 24, 28, 37, 41, 42, 46, 48, 50-52, 54, 57, 60, 62, 65] and used multivariate analyses (n=21), [16, 18, 19, 22, 24, 25, 28, 35, 37, 39, 41, 42, 44, 46, 47, 50, 52, 54, 60, 62, 65] suggesting that complications remained a significant independent predictor of patients' postoperative wellbeing even after controlling for a range of clinical and demographic factors. Domains of patients' wellbeing that were significantly negatively affected by surgical complications included physical, emotional, and social aspects of patients' quality of life as well as anxiety and depression levels (see Table 4). Complications that were found to be significantly associated with low levels of patient wellbeing included both major events such as perioperative myocardial infarctions after CABG, [50] severe incontinence after internal sphincterectomy [31] or graft-related events after vascular surgery, [65] and minor complications such as wound infections after hepatic resection, [20] or new cardiac arrhythmias after CABG. [54] The complications that were significantly associated with patients' post-operative wellbeing are presented in Tables 1-3.

Six studies reported a confounding association between surgical complications and patients' wellbeing (i.e. complications were significantly associated with worse wellbeing only under certain

conditions) [21, 32, 40] or complications were significantly associated with patients' wellbeing at univariate but not at multivariate analysis. [49, 59, 64] A total of 12 studies did not find a significant association of surgical complications with patients' postoperative wellbeing. [23, 26, 27, 29, 34, 38, 53, 55, 56, 61, 63, 66] The majority of them (n=7) scored below 6 on quality assessment. For example, four studies suffered from very small sample sizes. [26, 27, 34, 38]

-Table 4 -

Meta-analyses

A series of supplementary meta-analyses were conducted on each extracted outcome (i.e. quality of life, anxiety, depression). For a meta-analysis on Quality of life only studies that used the SF-scales were considered, as they were the most commonly used quality of life assessment tools. There were three studies with sufficient data on the physical and mental quality of life component scores, [28, 31, 45] and three studies with data on 'physical functioning' (i.e. limitations in performing physical activities), 'bodily pain' (i.e. limitations due to pain), 'role -physical ' (i.e. problems with daily activities as a result of physical health), and 'role -emotional' (i.e. problems with daily activities as a result of emotional health), [36, 37, 48] Moreover, there were four studies with sufficient data on 'general health' (i.e. evaluations of overall health), 'social role functioning' (i.e. interference with normal social activities due to physical and emotional problems), 'mental health' (i.e. feelings of nervousness and depression), and 'vitality' (i.e. feeling tired). [31, 36, 37, 48] The pooled mean differences between the two groups were significant for each quality of life sub-domain. The pooled differences were more than 5 points (on a scale from 0 to 100) for most of the sub-domains, indicating clinically meaningful [67] adverse effects of complications on the different quality of life domains (see supplementary materials). Two studies provided sufficient data for a meta-analysis on anxiety. [30, 62] The pooled SMD was not significant. A meta-analysis on depression was not possible as only one study provided sufficient data. [30]

For a more detailed report of the meta-analyses see the supplementary materials.

The duration of the impact of surgical complications on patients' wellbeing

Eighteen out of the 38 studies which reported significant associations (including the six studies which reported confounding findings) found a significant relationship of the presence of post-operative complications with lower levels of wellbeing at 12 months post-surgery or later. [16, 19-22, 25, 28, 30-33, 36, 37, 47, 48, 50, 51, 65] Twenty studies reported a significant association of complications with lower levels of patient wellbeing less than 12 months post-surgery. [17, 18, 24, 35, 39-46, 49, 52, 54, 57, 59, 60, 62, 64]

Discussion

This is, to our knowledge, the first systematic review of the literature assessing the impact of surgical complications on patients' psychosocial wellbeing. In line with our hypothesis, two thirds of the included studies found a significant negative association between the occurrence of surgical complications and patients' postoperative wellbeing. The vast majority of those studies were of high quality. For instance, more than half of the studies with significant findings found that complications were an independent predictor of patients' postoperative wellbeing after controlling for pre-existing differences on patients' wellbeing, clinical and demographic variables.

Significant associations were reported between surgical complications and lower scores not only on physical but also on emotional and social dimensions of the various quality of life measures. A meta-analysis of the studies that used the SF-scales confirmed the existence of significant and clinically meaningful adverse effects of complications on various domains of patients' quality of life including patients' mental health, social functioning and problems with daily activities as a result of emotional problems. These findings confirm earlier preliminary findings on the psychological burden that surgical adverse events often cause on patients. [3, 4] Surgical complications were also significantly associated with higher post-operative anxiety and depression in individual studies, even though a

population effect could not be shown in meta-analysis due to the very small number of studies that assessed anxiety and depression in relation to surgical complications. Despite the fact that quality of life is a useful screening outcome offering a general picture of a person's physical health and psychological state, [68] future studies on the psychosocial impact of surgical complications should focus more on outcomes such as anxiety and depression as they offer a more accurate picture of a person's psychological wellbeing. Highly relevant psychological outcomes such as post-traumatic stress that were not assessed in any of the included studies would also be of relevance for future research in this area.

Complications that were found to significantly contribute to patients' low post-operative wellbeing ranged from severe adverse events such as anastomotic leaks after gastro-intestinal surgery or perioperative myocardial infarctions after cardiac surgery to relatively minor complications such as wound infections or atrial fibrillation. It is not therefore only severe post-operative events that cause emotional distress and disruption during patients' convalescence but also less serious complications. Wound complications for instance may affect patients' satisfaction with their body image which may in turn affect their quality of life and psychological wellbeing. [69] Moreover, this finding shows that the severity of complications as judged by clinicians does not always relate to how patients experience complications or how severely they are affected by them. Similarly, complications were found to be negatively associated with patients' post-operative wellbeing not only after major surgical procedures but also after relatively minor operations, [30, 18, 28, 31, 43] which suggests a potential independence of the magnitude of initial surgery with the development of significant effect of complications on patients' wellbeing. Further research on how complications affect patients' wellbeing after different types of surgery will help elucidate the role of this factor.

A considerable number of studies also found a significant negative contribution of surgical complications to patients' psychosocial wellbeing more than a year post-operatively, suggesting that patients may suffer psychologically due to the experience of surgical complications for an extensive

period of time after their surgery. The above findings hold important implications for surgical patients' recovery. There is growing evidence on the role of psychological stress in compromising the function of the immune system and slowing down wound healing. [7-9] The emotional distress that surgical complications inflict on patients is likely to further compromise their recovery in almost a reciprocal cycle of distress and decreased immune function. The exact relationships between the occurrence of surgical complications, psychological distress and speed of recovery warrant further investigation.

It is noteworthy that a smaller number of studies did not find a significant association between complications and patients' postoperative wellbeing or found significant univariate associations which were not replicated in multivariate models. Even in studies showing a significant impact there will be many patients who largely maintain their psychological health and quality of life in the aftermath of complications. Other than clinical factors, factors such as patients' ways of coping with stress, their appraisals of surgery and their condition as well as their perceptions of support from their loved ones and the healthcare professionals may also explain under which conditions complications affect patients' psychosocial wellbeing, as suggested by wider literature on patients' adjustment after surgical treatment. [70- 72] The contribution of psychological factors in ameliorating the psychological impact of surgical complications needs to be further explored.

Overall the quality of the included studies was good as indicated by their relatively high quality assessment scores and the small number of studies that scored exceptionally low. A substantial number of studies with significant findings accounted not only for patients' pre-operative wellbeing but also for a host of other clinical and demographic factors in multivariate analyses confirming that surgical complications were an independent predictor of low levels of postoperative wellbeing above and beyond any pre-existing differences. The validity of the findings is also reinforced by the fact that all the included studies used validated self-report measures for the assessment of patients'

wellbeing, as well as by the use of a very comprehensive search strategy for the identification of relevant literature.

Limitations

A few caveats should be borne in mind when interpreting the above findings. Firstly, even though the majority of the included studies used predefined lists or definitions of complications one third of them did not define or describe the complications that were recorded, nor did they explain their methods of complications recording. Moreover, almost one third of the studies did not describe their response rates, which does not permit inferences about the representativeness of their samples. With regards to the methodology of the systematic review, studies that were published before the year 2000 or with the majority of patients recruited before the year 2000 were excluded. However, limiting this review to literature that was published in the last decade is more reflective of current surgical practices and their associated complications. Caution should also be taken when interpreting these findings to other specialties as the clinical setting in which complications occur may affect their impact on patients' wellbeing. Another limitation was the very small number of studies with sufficient data for quantitative synthesis and the difficulty of synthesising data from different quality of life measures, which resulted in restricting the meta-analyses on data collected only with the SF scales. The small number of studies with available data did not also permit certain types of sensitivity analyses such as by surgical specialty, type of surgery (i.e. minor versus major surgery) or underlying disease (e.g. cancer versus other conditions). These factors may be significant determinants of the extent to which complications negatively impact on patients' post-operative wellbeing. Future studies on the association of surgical complications with outcomes such as anxiety, depression and post-traumatic stress, other than allowing a more accurate investigation of the complications' psychological impact, would also permit fuller meta-analyses of these effects. Lastly,

there is always the potential for publication bias where studies with significant results and big effect sizes are more easily published. [73-75]

Implications of findings

The results highlight the importance of considering patients' psychological needs in the aftermath of complicated surgical recovery. Surgical and nursing staff need to be aware of the challenges of surgical complications for patients' wellbeing and ensure that their psychological needs are not neglected. Screening patients who suffer post-operative complications for symptoms of psychological distress could help clinical staff identify those patients who need psychological support. Facilitating patients' access to psychological support during their hospital stay and arrangements for follow-up support could also be of great value for patients' post-operative wellbeing. For example, early referral to psychological services and early psychological interventions could prevent long-term psychological distress and may also mitigate the negative effects of stress on patients' recovery. Primary care practitioners and carers need also to be aware of the psychological burden that surgical complications impose on patients' lives in order to recognise their distress in time and to provide the support that patients need.

Conclusions

This is the first systematic review of the literature on the impact of surgical complications on patients' psychosocial wellbeing. The findings of this review strongly suggest that surgical complications are a significant independent predictor of patients' impaired post-operative psychosocial wellbeing often for a very long time post-surgery. It is not only major complications that may compromise patients' psychosocial wellbeing but also relatively minor adverse events,

which implies that the clinical severity of complications does not always indicate how seriously patients will be affected by them. Patients who experience surgical complications report lower levels of different aspects of quality of life than patients with uncomplicated recovery, often more than a year after their operation. The ways in which complications are managed (e.g. reoperation versus conservative management), the type of surgery (e.g. minor versus major), the underlying disease (e.g. cancer versus other conditions), psychological mechanisms (e.g. patients' perceptions of support, illness perceptions, coping strategies) or cultural influences may be key factors that moderate the impact of surgical complications on patients' psychosocial wellbeing. Future research should try to disentangle the contribution of the above factors on the impact of surgical complications on patients' post-operative wellbeing. Lastly, future studies should try to understand the impact of surgical complications on psychological outcomes such as anxiety, depression and traumatic stress and how to better support patients who experience a complicated post-operative recovery.

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Contributions: All co-authors contributed to the study design and reviewed drafts of the article. The first author screened all the articles for inclusion in this review, extracted and synthesised the data, and appraised the study quality. RD screened a sample of these at title/abstract and full text, and AA extracted data and scored the quality of a sample of the included articles.

Data sharing: No additional unpublished data

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Table 1: Key characteristics of gastro-intestinal surgery studies (n=29)

First author's name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of surgical complications with patients' wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Anthony	2003	US	Secondary	Nt1=71/? Nt2=63 Nc=16	Colorectal cancer, male patients who underwent open surgical therapy	Observational, cohort, prospective	Open surgical therapy for colorectal cancer	*Morbidity* was defined as any event that resulted in the need for additional therapy or readmission to the hospital within 30 days of initial discharge/Method not specified	Quality of life (QOL)/at time of diagnosis and 12 months after surgery/FACT-C[1]	YES*	Any complications/12 months post- surgery	**6**
Avery	2006	UK	Primary	N=139/162 Nc=37	Patients with esophageal or gastric cancer who underwent upper gastro-intestinal surgical treatment	Observational, cross-sectional	Upper gastro-intestinal surgical treatment for esophageal or gastric cancer	A major complication was defined as reoperation, readmission to the high-dependency or intensive care unit, readmission to the hospital within 30 days of operation, or death within 30 days of operation or later if the patient did not leave the hospital/Method not specified	QOL/39.6days after treatment (range,6–105)/EORTC QLQ-C30[2]	YES	Any complications/39.6 days after treatment (range: 6–105)	**5**
Bitzer	2008	Germany	Secondary	Nt1=151/205 Nt2=130 (86.1%) Nc(complaints)=49 Nc(wound infection)=5 Nc(seroma)=13 Nc(pneumonia)=1 Nc(other)=28	Patients undergoing cholecystectomy	Observational, cohort, prospective	Cholecystectomy	Retrospective list: Any complaint, Wound infection, Seroma, Pneumonia, other complaints/Patient reports	QOL/14 days pre-op, 14 days post-op, and 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**7**
Bloemen	2009	Netherlands	Primary	N=121/170 Nc=33	Rectal cancer patients	Observational, cross-sectional	Surgical treatment for adenocarcinoma of the rectum	Only severe complications were considered: Grade III or IV complications (according to Dindo's model) were defined as severe, whereas absence of complications or Grade I and II complications were defined as absent or mild complications/patient records	QOL/36 (16–51) months post-op /EORTC QLQ-C30 & CR38[3]	YES	Severe post-operative complications/Median of 36 (range, 16–51) months post-surgery	**6**
Bruns	2010	Germany	Secondary	N=96/188 Nc(any morbidity)=30 Nc(wound infections)=10	Patients who underwent curative hepatic resection for malignant or non malignant diseases, disease free at time of assessment	Observational, cross-sectional	Hepatectomy	Surgical (e.g. bile leak or biloma, pneumothorax, wound infection, liver abscess, bleeding, and surgical dehiscence) and medical (e.g. pleural effusion, renal failure, hepatic failure, pneumonia, cardiac insufficiency, and cholangitis)/patient records	QOL/ 3-36 months post-op /SF-12	YES	Wound infections/3-36 months post-surgery	**5**

[1] Functional assessment of cancer therapy questionnaire with the colorectal module
[2] European Organisation for Research and Treatment of Cancer core
[3] European Organisation for Research and Treatment of colorectal cancer

Champault	2006	France	Secondary	Nt1=152/? Nt(4)=139 Nc=(unclear)	Consecutive patients operated on for morbid obesity.	Observational, cohort, prospective	Laparoscopic placement of a gastric band	Retrospective list: pulmonary atelectasis or pneumonia, prolonged ileus, minor wounds problems and urinary retention. Slippage with a peak incidence during the second postoperative year. Band erosion with penetration into the stomach. Access port problems (infection, hematoma, leak, disconnection), bands explanted, associated with erosion, obstruction, immediate intolerance, and recurrent tubing break/Method not specified	QOL/pre-op, 1, 3 months & 2 years post-op/GIQLI[4]	CONFOUNDING*	Band removal for complications such as erosion, slippage, intolerance/2 year post-surgery	**6**
Chang	2010	Taiwan	Secondary	N=102/218 Nc(anastomotic stricture)=12 Nc(gastrojejunal anastomotic ulcer) =9 Nc(upper gastro-intestinal bleeding) =1 N(GORD)=2	Patients undergoing bariatric surgery.	Observational, case-control, longitudinal	Roux-en-Y bypass	Operation related complications, including gastrojejunal anastomotic stricture, gastrojejunal anastomotic ulcer, upper gastro-intestinal bleeding and GORD/Method not specified	QOL/pre-op, 1, 3, 6 and 12 months post-op/WHOQOL-BREF[5]	YES*	Any complications/1, 3, 6, 12 months post-surgery	**5**
Dasgupta	2008	UK	Secondary	Nt1=102/122 Nt2=87 Nt3=80 Nt4=33 Nc=44	Consecutive, patients undergoing liver surgery for liver cancer	Observational, prospective, cohort	Liver resection for hepatic malignancies	Major complications were defined as those associated with systemic illness requiring transfer to a higher level of care (high-dependency or intensive care unit) or requiring relaparotomy, or complications needing interventional radiology/Method not specified	QOL/pre-op, 6, 12, 36-48 months post-op/EORTC QLQ-C30	NO*	N/A	**6**
Delaney	2003	US	Secondary	Nt1=109/109 Nt2=82/109 Nc(any)=19 Nc(major)=9	Patients with Crohn's Disease	Observational, cohort, prospective	Surgery for CD (abdominal perineal, loop or end stoma)	Retrospectively listed complications: anastomotic leak, intraabdominal abscess, bleeding, venous thrombosis, renal failure, and pneumonia, dehydration, intraabdominal abscess, small bowel obstruction and wound infection/Database review	QOL/pre-op & 30 days post-op/CGQL[6]	YES*	Any complications/30 days post-op	**7**
Douma	2011	Netherlands	Secondary	N=296/? Nc=?	296 patients with FAP who had been surgically treated	Observational, cross-sectional	Surgery for familial adenomatous polyposis (FAP)	Surgery-related complications/Self-reports + medical records	QOL/0 to >10 years post-op/SF-36, EORTC-QLQ-C38,Social Functioning subscale of the Dutch version of IBDQ[7]	YES	Any complications/0 to >10 years post-surgery	**2**
Dubernard	2006	France	Secondary	Nt1=58/? Nt2=58 Nc=9	Women with colorectal endometriosis who underwent a segmental colorectal resection	Observational, cohort, prospective	Laparoscopic segmentalcolorectal resection for endometriosis	Retrospectively listed complications: rectovaginal fistulae, vessel injury of the protective colostomy treated by laparoscopic coagulation, uroperitoneum requiring a ureteral stent for 6 weeks and an abscess behind colorectal anastomosis requiring a laparoscopic drainage/Patient observations	QOL/pre & post-op/SF-36	NO*	N/A	**6**
El-Awady	2009	Egypt	Secondary	N=40/? Nc=14	Patients with inguinal hernia	Observational, prospective, cohort	Anterior open Lichtenstein tension free hernioplasty	Postoperative complications: seroma, haematoma, 2ry infection, neuralgia and anaesthesia/patient observations	QOL/pre-op, 3, 6 &12 months post-op/SF-36	NO	N/A	**4**

[4] Gastrointestinal Quality of Life index
[5] World Health Organization Quality of Life – Brief
[6] Cleveland Global Quality of Life
[7] Inflammatory Bowel Disease Questionnaire

Hawn	2006	US	Primary	Nt1=1983/3518 Nt2=1526 (77%) Nt3=1603 (81%) Nc(neuralgia t1)=94 Nc(hematoma t1)=51 Nc(orchitis t1)=13 Nc(recurrence t1)=76 Nc(other t1)=124 Nc(neuralgia t2)=105 Nc(hematoma t2)=55 Nc(orchitis t2)=18 Nc(other t2)=150	Men who received a hernia repair.	Observational, cohort, prospective	Inguinal herniorrhaphy	Complications were summarized by 4 categories: (1) hematoma/seroma, (2) orchitis, (3) neuralgia of the leg or groin, and (4) other. Complications classified as "other" included: (1) early postoperative complications (urinary tract infection, urinary retention, and hematuria); (2) life-threatening complications (respiratory insufficiency, myocardial ischemia, cardiac arrhythmia, intraoperative hypotension, and stroke); and (3) long-term complications (4 weeks or more postoperative)/Patient reports for neuralgia & orchitis + Expert consensus for life-threatening complications	QOL/pre-op, 1 &2 years post-op/SF-36	YES*	Neuralgia, orchitis/2 years post-surgery	**8**
Ince	2011	US	Secondary	Nt1=?/568 Nt2=166 Nc=?	Patients who underwent colorectal resection for benign and malignant diseases.	Observational, cohort, retrospective	Laparoscopic colorectal resection	No reference	QOL/pre-op, 4weeks post-op/SF-36	NO*	N/A	**3**
Kalliomaki	2009	Sweden	Primary	N(total)=184/423 N1=92 (cases) N2=92 (controls)	Patients who had been operated on for groin hernia. Controls matched for age, gender and method of surgical repair were allotted from the group of persons without persisting pain (Grade 1 in IPQ)	Observational, case-control, cross-sectional	Hernia repair	Persistent postoperative pain (patients with pain of Grade 3, i.e. pain that could not be ignored but did not interfere with everyday activities, or higher on IPQ)/Patient reports (Inguinal Pain Questionnaire) & clinical examination	QOL, anxiety, depression/(on average 4.9 years post-op, range > 7 years)/SF-36, HADS[8]	YES	Persistent post-op/Mean of 4.9 years post-surgery	5
Kement	2011	Turkey	Primary	N=253/351 N(incontinence)=28 N(severe incont)=9 N(mild incont)=19	Consecutive patients with chronic anal fissure who underwent open LIS.	Observational, cross-sectional	Open lateral internal sphincterotomy	Anal incontinence/Patient reports: Wexner Incontinence Score system (WIS) + Clinical examination	QOL/23.3 +/- 7.1 months post-op/SF-36	YES	Severe incontinence/23.3 (SD ± 7.1) months post-surgery	**5**
Lim	2006	UK	Primary	N=92/112 Nc(leaks)=23 Nc(clinical leaks)=13 Nc(sub-clinical leaks)=10	Consecutive patients under the care of three consultant surgeons who underwent procedures with LRA	Observational, cross-sectional	Low rectal anastomosis (LRA)	Anastomotic leaks (clinical & subclinical)/Patient observations, CT scans, WCE	QOL/10-18 months post-op/EORTC QOL	CONFOUNDING	Anastomotic leaks/10-18 months post-op	**5**

8 Hospital Anxiety and Depression Scale

Liu	2010	US	Primary	N=679/1308 Nc(early comps/anast)=54 Nc(late comps/anast)=126 Nc(early comps/anast/rectal cancer only)=42 Nc(late comps/ostom/rectal cancer only)=105	Long-term Colorectal Cancer patients	Observational, cross-sectional	Colorectal cancer surgery	-Digestive, skin, genitourinary, surgical, medical, immediate indirect complications -Early complications: those that were first recorded within 30 days of the surgery. Late complications: occurring 31 days after surgery/Patient computerised data	QOL/ 5-15 years post-op/mCOH-QOL-Ostomy[9]	YES	Enterocutaneous fistula for all patients & any late complications for ostomy patients>5 years post-surgery	**6**
Mentes	2006	Turkey	Primary	Nt1=253/302 Nt2=244 Nc(anal fistula/abscess)=3 Nc(FISI>0)=7 Nc(FISI, 0->4, 21, 7)=3	Patients who underwent Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Observational, cohort, prospective	Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Anal Incontinence/Patient examination+ FISI score	QOL/pre-op (admission) & 12 months post-op/GIQLI & FIQL[10]	UNCLEAR (due to small number of patients with complications)	N/A	**6**
Pittman	2008	US	Primary	N=239/322 Nc=56	Veterans with an ostomy after major gastro-intestinal surgery requiring an intestinal stoma	Observational, case-control, cross-sectional	Gastro-intestinal surgery requiring an intestinal stoma	Ostomy complications: skin problems, leakage, and difficulty with adjustment (i.e. leakage, peristomal irritant dermitis, pain, bleeding, stomal necrosis, prolapse, stenosis, herniation, retraction, infection, mucotaneous separation, difficulty adjusting)/Patient reports	QOL/6months post-op/mCOH-QOL-Ostomy	YES	Ostomy complications (skin problems, leakage)/ 6 months post-surgery	**6**
Polese	2012	Italy	Primary	N=147/211 Nc(anastomotic stenoses)=22	Patients who underwent elective left colonic or rectal resection and colorectal anastomosis for neoplastic or inflammatory disease.	Observational, cross-sectional	Left colonic or rectal resection and colorectal anastomosis	Anastomotic stenosis/Clinical examination	QOL/mean 58 (SD ± 31) months post-op/SF-36	YES	Anastomotic stenosis/58 (SD ± 31) months post-surgery	**6**
Rea	2007	US	Primary	Nt1=505/? Nt2=237 Nt3=106 Nc(t2)=41 Nc(t3)=23	Patients who underwent LRYGB by one surgeon for morbid obesity	Observational, cohort, prospective	LRYGB for morbid obesity without conversion to an open procedure.	Postoperative complications requiring intervention/Method not specified	QOL/baseline, 1 & 2 years post-op/SF-36	YES*	Complications requiring intervention/1 & 2 years post-surgery	**6**

9 City of Hope Quality of Life for Ostomates questionnaire
10 Fecal Incontinence Quality of Life Instrument

Riss	2011	Austria	Primary	N1=16/36 (cases) N2=16/? (controls)	Cases: patients operated for rectal cancer and developed anastomotic leak. Controls: Patients operated for rectal cancer at the same time period and had an uneventful postoperative course matched by sex, age (±5 years), type of resection, and neoadjuvant therapy.	Observational, case-control, cross-sectional	Rectal resection for malignancies on overall pelvic organ function	Anastomotic leakage: Defined as grade A (no change in patient's management), grade B (requires active therapeutic intervention but is managed without relaparotomy) and grade C (requires relaparotomy)/Review of the institutional colorectal database and individual chart reviews	QOL/106.8 months post-op (32.4–170.4)/SF-12	NO	N/A	**7**
Rutegard	2008	Sweden	Secondary	N=355/ 446 (79·6 %) Nc=56	Patients diagnosed with an oesophageal or cardia cancer who underwent macroscopically and microscopically radical resection	Observational, cross-sectional	Oesophageal resection	Technical surgical complications, including postoperative bleed exceeding 2000 ml or requiring a reoperation, anastomotic insufficiency, necrosis of the substitute, damage to the recurrent nerve, thoracic duct damage or gastric perforation/Prospective scrutiny of medical and histopathological records, operation charts, extensive study protocol with predefined exposure alternatives	QOL/6months post-op/EORT QLQ-C30, & QLQ-OES1812 [11]	YES	Technical complications/6 months post-surgery	**7**
Scarpa	2009	Italy	Secondary	N=47/? Nc=?	Patients admitted for intestinal surgery for Crohn's Disease	Observational, cross-sectional	Bowel resection through midline laparotomy or with laparoscopic assistance, end ileostomy, stricturoplasty	Medical and surgical complications and need of reoperation (2 anastomotic leaks, 3 intestinal obstructions, 2 intestinal bleeding, and a wound infection were recorded and two re-laparotomies)/Method not specified	QOL/3 months post-op/CGQLI	CONFOUNDING	Any complications/3 months post-surgery	**3**
Sharma	2007	UK	Secondary	Nt1=104 /110 Nt2=92 Nc=41	Consecutive patients with newly diagnosed colorectal cancer scheduled for elective open resection in one hospital trust	Observational, cohort, prospective	Elective resection for colorectal cancer	Wound, urinary tract and chest infections, cardiac and respiratory complications, deep venous thrombosis, pulmonary embolism and complications related to anastomotic breakdown/Method not specified	QOL, anxiety, depression, positive vs. negative affectivity, mood states/pre-op (5-12 days pre-op) & 6-8 weeks post-op/FACT-C, EuroQOL (EQ-5D), HADS, PANAS[12], MRS[13]	YES*	Complications within 30 days of operation/6-8 weeks post-surgery	**6**
Siassi	2009	Germany	Secondary	Nt1=93/113 Nt2,t3=79 Nc=26	Patients undergoing colorectal surgery for benign and malignant disease	Observational, prospective, cohort	Resection of the sigmoid colon or rectum	Postoperative complications (anastomotic leak, wound infection, delayed food intake, fever, and bladder dysfunction)/Method not specified	QOL/pre-op, 3 & 12 months post-op/SF-36 & GLQI[14]	YES*	Any complications/3 months post-surgery	**7**

[11] Oesophageal cancer-specific questionnaire
[12] Positive and negative affect schedule
[13] Mood rating scale
[14] Gastrointestinal Quality of Life Index

Targarona	2004	Spain	Primary	N=37/46 Nc(recurrent hernias)=3	Patients diagnosed with paraesophageal or mixed hiatal hernia (types II, III, and IV) with >50% of the stomach in the chest.	Observational, cross-sectional	Laparoscopic repair of paraesophageal hiatal hernia	Hernia recurrence (any migration of the cardia to chest level or evidence of a new paraesophageal sac)/A barium swallow was given to all patients to rule out an anatomic recurrence. An independent radiologist evaluated all the explorations.	QOL/>=6 months post-op (median, 24; range, 6–50)/SF-36, GDSS[15] and GIQLI	YES	Clinically recurrent hernias/>=6 months post-surgery	**5**
Viklund	2005	Sweden	Secondary	N=100/146 Nc=44	Patients newly diagnosed with a histologically verified adenocarcinoma or squamous-cell carcinoma of the esophagus or adenocarcinoma of the gastric cardia that underwent macroscopically and microscopically radical tumor resection.	Observational, cross-sectional	Esophageal resection surgery for cancer	Anastomotic leakage , infections, respiratory insufficiency, cardiac complications, technical complications, anastomotic strictures, and others (intervention needed to treat embolus, deep venous thrombosis, rupture of the wound, intestinal obstruction, stroke, renal failure, or liver failure)/Patient records	QOL/6 months post-discharge/QLQ-C30 & OES-24[16]	YES	Any complications, anastomotic leakage, infection, respiratory insufficiency, cardiac complications, technical complications/6 months post-discharge	**7**

***Study controlled for patients' preoperative wellbeing**

[15] Glasgow Dyspepsia Severity Score
[16] Symptoms specific to oesophageal cancer

Table 2: Key characteristics of cardio-thoracic surgery studies (n=17)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Deaton	2009	US	Secondary	Nt1= 317/442 Nt2=270 Nc=44% (130)	Patients with documented T2DM undergoing CABG	Observational, cohort, prospective	CABG	Infection of the leg, thorax, sternum, bloodstream or urinary tract; central neurological deficit (stroke or transient ischemia, coma); pneumonia, pulmonary insufficiency with prolonged ventilation or re-intubation, pulmonary embolism; renal failure; arrhythmias requiring treatment; prolonged inotropic support or use of intra-aortic balloon pump; or reoperation for bleeding or tamponade/Patient records	QOL/ 3 months post-op/SF-36	YES	Any complications/3 months post-surgery	**6**
El Baz	2008	Netherlands	Secondary	Nt1=198/256 Nt2=168 Nc=?	Consecutive patients who were scheduled for CABG following a coronary angiography	Observational, cohort, prospective	CABG	Postoperative events such as use of inotropes, atrial arrhythmias, or ventricular arrhythmias, sternal resuturing, re-exploration for bleeding, and time spent on mechanical ventilation/Registry database, medical notes, outpatient notes and intensive therapy unit charts	QOL/pre-op & 6 months post-op/SF-36	YES*	Re-exploration for bleeding and sternal resuturing/6 months post-surgery	**8**
Ferguson	2009	US	Primary	N=124/221 Nc=22	Prospective patients who underwent major lung resection for early stage lung cancer.	Observational, cross-sectional	Major lung resection for early stage lung cancer (lobectomy, bilobectomy, pneumonectomy)	Complications were categorized as pulmonary (pneumonia, prolonged intubation, reintubation, air leak more than 7 days, lobar collapse requiring intervention), cardiovascular (pulmonary embolism, myocardial infarction, new postoperative arrhythmia, need for intravenous inotropic agents), other, and any complication/Administrative database, hospital medical records, office shadow files	QOL/average of 2.6 years post-op (3 months to 6.4 years)/EORTC QLQ-C30, EORTC QLQLC13[17] and DASS-21[18]	YES	Pulmonary complications/2.6 years post-surgery (Range: 3 months-6.4 years)	**6**
Gjeilo	2010	Norway	Primary	Nt1=534/631 Nt2=462 Nt3=465 Nc(t2)=52	Patients undergoing cardiac surgery	Observational, cohort, prospective	Midline sternotomy	Chronic pain (pain arising after surgery and persisting either continuously or intermittently for 3 months or more/BPI (Brief Pain Inventory)	QOL/pre-op, 6 & 12 months post-op/SF-36	YES*	Chronic post-surgical pain/12 months post-surgery	**6**
Hata	2006	Japan	Secondary	N=452/452 Nc=?	Consecutive adult patients who underwent open heart surgery	Observational, cross-sectional	CABG	Postoperative morbidity (minor stroke, infection, pneumonia, haemodialysis, paraplesis)/Patient records	Depression/5-7 days post-op/Interviewed by a psychiatrist and CES-D[19]	CONFOUNDING	Post-operative minor stroke and pneumonia/5-7 days post-surgery	**6**

17 EORTC Lung Cancer Questionnaire
18 Short version of the Depression Anxiety Stress Scales
19 Center for Epidemiological Studies Depression Scale

Jarvinen	2004	Finland	Primary	Nt1=501/1128 Nt2=485 Nc=80	Patients who underwent CABG	Observational, cohort, prospective	CABG [89% via sternotomy incision with cardiopulmonary bypass (CPB; on-pump) and 11% without CPB (off-pump)]	Perioperative myocardial infarctions/Clinical examination + clinical tests (ECGs, echocardiography, laboratory tests)	QOL/pre-op & 12 months post-op/RAND-36	YES*	Perioperative myocardial infarctions /12 months post-surgery	**7**
Jideus	2009	Sweden	Primary	N1=73/84 (cases) N2=42/? (controls)	-Cases: patients who developed sternal wound infection (SWI) after cardiopulmonary bypass. -Controls: patients prior to CABG and evaluated 1 year postoperative and matched for time of the operation, age and sex	Observational, case-control, cross-sectional	Cardiopulmonary bypass	Serious wound infections (SWIs: deep infection involving retrosternal tissue and/or the sternal bone)/Clinical examination	QOL/20 months post-op (range 7-40)/SF-36	YES*	Serious wound infections /20 (Range: 7-40) months post-surgery	**4**
Kinney	2012	US	Primary	N=99 Nt1=120/? Nt2=99 Nc=75	Patients aged 45 to 75 years undergoing elective thoracotomy	Observational, cohort, prospective	Serratus-sparing posterolateral thoracotomy or limited thoracotomy	Chronic post-thoracotomy pain/Leeds Assessment of Neuropathic Symptoms and Signs + self-reports	QOL/pre-op, 3 moths post-op/SF-36	YES*	Chronic post-thoracotomy pain/ 3 months post-surgery	**7**
Landoni	2006	Italy	Primary	N1=22/42 (cases) N2=40/42 (controls)	-Cases: patients who underwent cardiac surgery and developed ARF requiring RRT and left the hospital alive. -Controls: matched controls who did not develop ARF and did not receive RRT.	Observational, case-control, cross-sectional	Cardiac surgery (procedures not specified)	ARF (acute renal failure) requiring RRT (renal replacement therapy)/Administrative database, registry	QOL/23-42 months post-op/SF-36	NO	N/A	**`6**
Le Grande	2006	Australia	Secondary	Nt1=182/444 Nt2=128 Nt3=114 Nc=?	Adults on the waiting list for CABG	Observational, cohort, prospective	CABG	Post-surgical complications such as cardiac arrhythmias, stroke and infections/Medical records	QOL/pre-op, 2 & 6 months post-op/SF-36	YES*	New cardiac arrhythmia post-surgery, atrial fibrillation/ 6 months post-surgery	**7**
Martin	2008	US	Primary	Nt1=836/2,007 Nt2=2.007 Nc=189	Patients undergoing elective open heart surgery	Observational, cohort, prospective	Open heart surgery (133 valve procedure; 620 CABG; 67 CABG plus valve procedure; 15 CABG plus other cardiac procedure; and 1 closure of an atrial septal defect)	Perioperative myocardial infarction, mediastinitis, superficial wound infection, septicemia, permanent stroke, transient ischemic attack, continuous coma, prolonged intubation, ventilator-associated pneumonia, cardiac tamponade, atrial fibrillation, reoperation for bleeding, renal failure, renal failure which required dialysis, and length of stay/Method not specified	QOL/pre-op, 1 year post-op/SF-20	NO*	N/A	**6**
Merkouris	2009	Greece	Secondary	Nt1=63/63 Nt2=59 Nt3=56 Nc=42	All patients over 65 presenting a 1, 2 or 3 vessel disease treated with CABG without concurrent procedures (e.g. valve replacement)	Observational, cohort, prospective	CABG	Retrospective list of complications: Atrial fibrillation, re-exploration for bleeding, low cardiac output syndrome, acute respiratory failure, sternal wound infection, neurological dysfunction, mild problems related to leg incision healing or swelling, chest incision discomfort and medications/Method not specified	QOL/pre-op, 4 & 12 months post-op/MacNew Heart Disease HRQOL questionnaire	NO*	N/A	**5**

Moller	2012	Sweden	Secondary	Nt1=249/? Nt2=213 Nc=?	Prospective patients scheduled for lung surgery for lung cancer	Observational, cohort, prospective	Lung surgery	Complication was defined as any of the following postoperative complications: new onset atrial fibrillation, prolonged air leak (chest tubes in place for more than 5 days), pneumonia, re-intubation, reoperation, or hospital stay of 8 days or more/Method not specified	QOL/pre-op, 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**6**
Myles	2001 & 2006	Australia	Secondary	Nt1=120/125 Nt2=120 (days 1,2,3) Nt3=108 Nt4=94 Nc=69	Adult cardiac surgical patients	Observational, cohort, prospective	Cardiac surgery (specific procedures not specified)	1. Respiratory: postoperative mechanical ventilation for more than 24 h or pneumonia, defined as pulmonary infiltrate with positive microbial cultures; 2. Cardiac: arrhythmia requiring treatment with antiarrhythmic medication or electrical cardioversion reversion; radiologic evidence of pulmonary edema; or myocardial infarction, defined by new Q waves on electrocardiogram or creatine kinase-MB isoenzyme concentration greater than twice normal; 3. Renal: acute renal failure, defined by serum creatinine concentration greater than 200 M; 4. Neurologic: stroke, defined as a new central neurologic deficit; 5. Sepsis: wound infection requiring excision of tissue or antibiotic therapy, or positive microbial culture (other than pneumonia) -Clinical and laboratory tests (microbial cultures, radiologic data, electrocardiograms etc.)	QOL/pre-op, 1 & 3 months, 3 years post-op/SF-36	CONFOUNDING*	Any complications/3 months post-surgery	**8**
Peric	2008	Serbia & Montenegro	Secondary	Nt1=208/? Nt2=192 Nc=60	Consecutive patients who underwent elective CABG	Observational, cohort, prospective	CABG	Retrospective list of complications: low cardiac output (cardiac index lower than 2 L/min/m2), mechanical ventilation longer than 24 hours, reoperation for bleeding, sternal wound infection, perioperative myocardial infarction, pericardial effusion, arrhythmic complications (atrial fibrillation, ventricular tachycardia, ventricular fibrillation), abdominal complications, and other/Observations, ECGs, echocardiography, laboratory tests	QOL/pre-op, 6 months post-op/Nottingham Health Profile Questionnaire (NHP)	YES*	Any complications/6 months post-surgery	**7**
Rodriguez	2008	US	Secondary	Nt1=397/? Nt2=? Nt3=? Nt4=? Nc=23	Patients diagnosed with upper extremity HH treated with TS.	Observational, cohort, prospective	Thoracoscopic sympathectomy for palmar and axillary hyperhidrosis	-Compensatory sweating (CS): Excessive sweating considered abnormal in other parts of the body after TS. -Gustatory sweating: Facial sweating after eating foods -Excessive dryness: Dryness affecting the hands and requiring hydration -Method not specified	QOL/pre-op, discharge, 6 & 12 months post-op/SF-36	NO*	N/A	**3**
Tully	2011	Australia	Primary	Nt1=226/238 Nt2=222 Nc=56	Patients undergoing first-time CABG surgery	Observational, cohort, prospective	CABG	New-onset atrial fibrillation (AF) between the patient's day of admission to the intensive care unit and the median day of discharge (day 5) after CABG during the index hospitalization/ECGs, transthoracic echocardiographs reviewed by technicians and reviewers blinded to patients' psychological distress scores	Anxiety, Depression, Stress/pre-op (mean=2 days, SD=2 days) & post-op (mean=6 days, SD=2 days)/ DASS[20]	YES*	Atrial fibrillation/6 days (SD=2 days) post-surgery	**7**

***Study controlled for patients' preoperative wellbeing**

[20] Depression Anxiety Stress Scales

Table 3: Key characteristics of studies in vascular surgery (n=4)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome & timepoints	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Lohse	2009	Germany	Secondary	N=110/124 Nc=?	Consecutive patients who received a replacement of the dilated ascending aorta.	Observational, cross-sectional	Ascending aorta replacement	Retrospective list: Postoperative bleeding, Myocardial infarction, Stroke, Pneumonia, Respiratory insufficiency, Acute renal dysfunction, Sepsis, Lung fistula/Method not specified	QOL/36.4 ± 15.5 months post-op (11–58 months)/SF-36	NO	N/A	**4**
Nguyen[a]	2007	US & Canada	Primary	Nt1=1296/1404 Nt2=862 Nt3=732 Nc=543	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Lower extremity vein bypass for limb salvage in critical limb ischemia (CLI) patients	Wound complications (WC): patients having infection, necrosis, hematoma-haemorrhage, or seroma-lymphocele at the surgical incision or harvest site within 30 days of the bypass surgery/Adverse events clinical trial documentation with reference to source documentation (hospital notes etc.)	QOL/baseline, 3 & 12 months post-op/VascuQol[21]	CONFOUNDING*	Wound complications/3 months post-surgery	**8**
Nguyen[b]	2006	US & Canada	Secondary	N1=1296/1404 (92.3%) N2=862 (61.4%) N3=732 (52.1%) Nc=?	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Infrainguinal vein grafting for limb salvage in critical limb ischemia (CLI) patients	Graft-related events (GREs): development of a >70% graft stenosis or having undergone a percutaneous or surgical revision or a major amputation/Clinical tests (angiography, ultrasonography etc.), source documentation (hospital notes, discharge notes, operative and procedural notes etc.)	QOL/pre-op, 3 & 12 months post-op/VascuQol	YES*	Graft-related events/12 months post-surgery	**8**
Subramonia	2005	UK	Primary	Nt1=70/70 Nt2=59 Nt3=62 Nc(sensory abnormalities)=25 Nc(bruising at t1)=58 Nc(bruising at t2)=16	Patients with varicose veins, either symptomatic or with skin changes, resulting from incompetence of the LSV as confirmed by handheld Doppler examination or duplex ultrasonography or both and requiring surgical intervention (both day cases and inpatients).	Observational, cohort, prospective	Conventional LSV stripping	-Bruising/Tracing method -Sensory abnormalities, both subjective (paresthesia and dysesthesia) and objective/Patient reports, sensory testing	QOL/pre-op, discharge & 6 weeks post-op/Aberdeen Varicose Vein Questionnaire 2	NO*	N/A	**7**

***Study controlled for patients' preoperative wellbein**

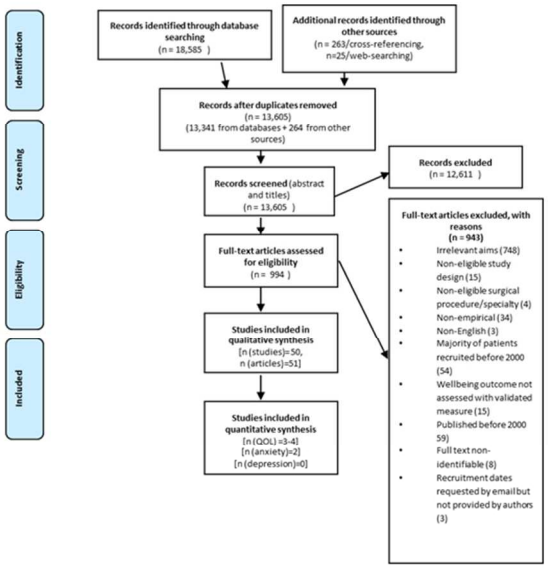
[21] A validated instrument assessing pain, symptoms, activities, social life and emotional state in patients with vascular disease

Table 4: Domains of patients' wellbeing that were significantly affected by surgical complications

		Studies																														
Measures		Bruns	Liu	Bloemen	Siassi	Rutegard	Pittman	Sharma	Avery	Le Grande	Nguyen [b]	Viklund	Delaney	Kalliomaki	Hawn	Anthony	Chang	Douma	Kement	Targarona	Peric	El Baz	Deaton	Ferguson	Tully	Gjeilo	Jideus	Kinney	Polese	Rea	Bitzer	Jarvinen	Moller
Short Form scales (e.g. SF-36, SF-12 RAND-36)	Physical-Component	✓			✓					✓					✓			✓	✓				✓									✓	
	Mental Component									✓					✓				✓				✓										
	Physical functioning													✓												✓	✓	✓				✓	✓
	Bodily pain													✓					✓							✓		✓	✓	✓	✓		
	Role physical													✓												✓			✓	✓	✓	✓	
	Role emotional													✓															✓				
	General health													✓					✓							✓	✓		✓	✓		✓	✓
	Mental health													✓								✓				✓			✓	✓			
	Social functioning													✓					✓							✓	✓		✓	✓			
	Vitality													✓					✓			✓				✓		✓		✓			✓
EORTC QLQ-C30+	Physical Functioning			✓		✓			✓	✓		✓						✓						✓									
	Global QOL					✓				✓		✓																					
	Social Functioning								✓																								
	Fatigue			✓		✓																											
	Role functioning					✓			✓																								
	Pain			✓																												
	Weight loss			✓																												

	Dyspnea					✓																									
	Nausea-Vomiting					✓			✓																						
	Coughing						✓																								
	Defecation																	✓													
VascuQOL	Total QOL										✓																				
GIQLI	Total QOL																		✓												
mCOH-QOL	Total QOL		✓																												
	Physical QOL						✓																								
	Social QOL						✓																								
FACT-C	Total QOL													✓																	
	Physical wellbeing							✓						✓																	
	Social wellbeing													✓																	
	Cancer concerns													✓																	
CGQL	Total QOL											✓																			
WHOQOL-BREF	Physical domain														✓																
	Pain & discomfort														✓																
	Activities of daily living														✓																
IBDQ	Social functioning															✓															
NHP	Social isolation																			✓											
	Sleep																			✓											
	Pain																			✓											
HADS & DASS	Anxiety							✓					✓											✓							
	Depression							✓					✓																		
PANAS	Negative affect							✓																							
MRS	Negative mood							✓																							

Figure 1: PRISMA flow diagram of study selection



254x190mm (96 x 96 DPI)

Supplementary materials for manuscript entitled:

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

Supplementary material 1: Search strategies

Embase

1. exp mental stress/
2. exp emotion/
3. exp depression/
4. exp ANXIETY/
5. exp posttraumatic stress disorder/
6. exp "quality of life"/
7. exp wellbeing/
8. 1 or 2 or 3 or 4 or 5 or 6 or 7
9. exp surgery/
10. exp complication/
11. 9 and 10
12. exp surgery/co [Complication]
13. exp perioperative complication/
14. exp peroperative complication/
15. exp postoperative complication/
16. exp preoperative complication/
17. exp surgical error/
18. exp iatrogenic disease/su [surgery]
19. exp anesthesia complication/
20. exp ANESTHESIA/co [Complication]
21. exp anesthesia/
22. exp complication/
23. 21 and 22
24. 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 23
25. exp patient/
26. adult/
27. female/
28. male/
29. 25 or 26 or 27 or 28
30. 8 and 24 and 29
31. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or awareness or iatrogen* or ((adverse or unfavourable or unfavorable or untoward or undesired) adj (outcome*1 or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
32. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or per-operative or peroperative or intra-operative or intraoperative or intra operative or anesth* or anaesth*).ti,ab.
33. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
34. 31 and 32 and 33
35. 30 or 34
36. limit 35 to (human and English language)

MEDLINE

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Stress, Psychological/
9. exp Emotions/
10. exp Depression/
11. exp Anxiety/
12. exp Stress Disorders, Post-Traumatic/
13. exp "Quality of Life"/
14. 8 or 9 or 10 or 11 or 12 or 13
15. exp Medical Errors/
16. exp Postoperative Complications/
17. exp iatrogenic disease/su [surgery]
18. exp Anesthesia/ae, co [Adverse Effects, Complications]
19. 15 or 16 or 17 or 18
20. 14 and 19
21. exp Patients/
22. exp adult/
23. exp women/
24. exp men/
25. exp research subjects/
26. 21 or 22 or 23 or 24 or 25
27. 14 and 19 and 26
28. 7 or 27
29. limit 28 to (English language and humans)

PsycINFO

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Psychological Stress/
9. exp emotions/
10. exp "depression (emotion)"/
11. exp Anxiety/
12. exp posttraumatic stress disorder/
13. exp "Quality of Life"/
14. exp well being/
15. 8 or 9 or 10 or 11 or 12 or 13 or 14
16. exp postsurgical complications/
17. exp patients/
18. exp Human Females/
19. exp human males/
20. 17 or 18 or 19
21. 15 and 16 and 20
22. 7 or 21
23. limit 22 to (human and English language)

Supplementary material 2:

Detailed report of meta-analyses on the impact of complications on patients' psychosocial wellbeing

Quality of life

Due to the different measurement tools that were used for the assessment of QOL as well as the different domains that each tool assesses, a meta-analysis was conducted only on the studies that used the SF-tools. These were the most commonly used tools for the assessment of QoL, they are not condition-specific and they use the same measurement scale. Moreover, all of them yield the same summary scores (i.e. physical and mental) and the sub-scores (i.e. Physical functioning, Bodily pain, Role limitations due to physical health problems, Role limitations due to emotional health problems, General health, Mental health, Social functioning, Vitality). [1] A meta-analysis was conducted on each sub-score. The effect sizes are expressed as mean differences (MD) on a scale ranging from 0 to 100.

Only three studies provided sufficient data for a meta-analysis on the physical and mental component scores of quality of life between patients with complications and patients without complications. [2-4] The pooled mean differences for the physical and mental summary scores between the two groups indicated significantly lower levels of physical and mental quality of life in patients who suffered complications compared to patients without complications (see eTable1).

Three studies [5-7] provided sufficient data for a quantitative synthesis on 'physical functioning' (i.e. limitations in performing physical activities), 'bodily pain' (i.e. limitations experienced due to pain), 'role -physical ' (i.e. problems with work/daily activities as a result of physical health), and 'role -emotional' (i.e. problems with work/ daily activities as a result of emotional health). The pooled mean differences between the two groups were significant and more than 5 points, indicating clinically meaningful [1] adverse effects of complications on each of the above domains of quality of life (see eTable1). Four studies [4-7] provided sufficient data for a meta-analysis of the differences on 'general health' (i.e. evaluations of overall health), 'social role functioning' (i.e. degree of interference with normal social activities due to physical and emotional problems), 'mental health' (i.e. feelings of nervousness and depression vs. feeling peaceful and happy), and 'vitality' (i.e. feeling tired vs. feeling full of energy). The pooled mean differences between the two groups were again significant and clinically meaningful on each sub-domain (i.e. more than 5 points) (see eTable1).

The estimates of heterogeneity (I^2) were low for the majority of the SF scores (<25%). High heterogeneity was observed only for mental health (78%), bodily pain (70%), and general health (81%). A sensitivity analysis by the methodological quality of the included studies revealed that when a study that scored low in quality assessment was excluded, [4] the pooled mean differences for mental health and general health increased indicating even higher adverse effects of complications on these two domains.

Anxiety and Depression

Two studies provided sufficient data for a meta-analysis on anxiety levels. [8, 9] Each study used a different scale, therefore the effect sizes are expressed as standardised mean differences (SMD). The pooled SMD for anxiety was not significant indicating a lack of population effect in terms of the complications' impact on patients' anxiety levels. The estimate of heterogeneity was high (I^2=81%), however a sensitivity analysis by the methodological quality of the included studies did not alter the results. A meta-analysis on depression was not possible as only one study provided sufficient data. [8]

Supplementary material 3

Table: Results of meta-analyses on the impact of complications on patients' psychosocial wellbeing

Wellbeing outcome	Sub-score	Comparison	k	N	Z	*P*	MD (SMD/anxiety)	95% CI	I^2
Quality of life (SF-scales)	Physical component	Complications vs.	3	244	4.51	0.00001	-3.28	-4.71, -1.86	20%
		No complications		1638					
	Mental component	Complications vs.	3	244	6.52	0.00001	-3.82	-4.97, -2.67	0%
		No complications		1638					
	Physical functioning	Complications vs.	3	97	2.34	0.02	-5.26	-9.67, -0.85	20%
		No complications		610					
	Bodily pain	Complications vs.	3	97	3.70	0.0002	-15.05	-23.04, -7.07	70%
		No complications		610					
	Role physical	Complications vs.	3	97	2.58	0.010	-11.56	-20.33, -2.78	48%
		No complications		610					
	Role emotional	Complications vs.	3	97	2.65	0.008	-8.63	-15.00, -2.25	25%
		No complications		610					
	General health	Complications vs.	4	106	2.51	0.01	-13.71	-24.40, -3.02	82%
		No complications		629					

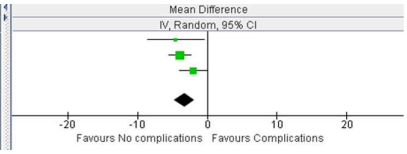
	Mental health	Complications vs. No complications	4	106 629	5.01	0.00001	-9.33	-12.97, -5.68	0%
	Social functioning	Complications vs. No complications	4	106 629	6.93	0.00001	-9.95	-12.76, -7.14	0%
	Vitality	Complications vs. No complications	4	106 629	5.15	0.00001	-10.63	-14.67, -6.58	0%
Anxiety		Complications vs. No complications	2	148 262	1.12	0.26	0.27	-0.21, 0.75	81%

Supplementary material 4:

Forest plots of meta-analyses on the impact of complications on patients' wellbeing

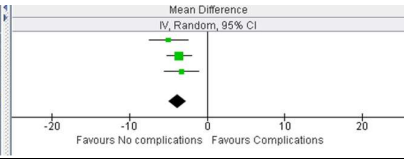
SF Physical summary score (SF PCS)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
20-Hawn	41.2	16.0186	105	45.7	52.9351	1479	11.3%	-4.50 [-8.58, -0.42]
28-Kement	53.97	2.22	9	57.91	1.63	19	51.5%	-3.94 [-5.57, -2.31]
39-Deaton	41	9	130	43	8	140	37.2%	-2.00 [-4.04, 0.04]
Total (95% CI)			244			1638	100.0%	-3.28 [-4.71, -1.86]
Heterogeneity: Tau² = 0.34; Chi² = 2.49, df = 2 (P = 0.29); I² = 20%								
Test for overall effect: Z = 4.51 (P < 0.00001)								



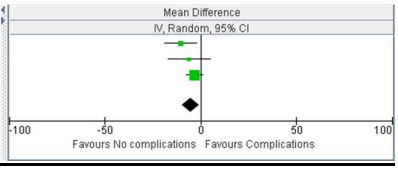
SF Mental summary score (SF MCS)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
39-Deaton	43	11	130	48	10	140	20.9%	-5.00 [-7.51, -2.49]
28-Kement	47.17	1.96	9	50.79	2.09	19	52.3%	-3.62 [-5.21, -2.03]
20-Hawn	47.1	10.3346	105	50.4	19.6056	1479	26.9%	-3.30 [-5.51, -1.09]
Total (95% CI)			244			1638	100.0%	-3.82 [-4.97, -2.67]
Heterogeneity: Tau² = 0.00; Chi² = 1.12, df = 2 (P = 0.57); I² = 0%								
Test for overall effect: Z = 6.52 (P < 0.00001)								



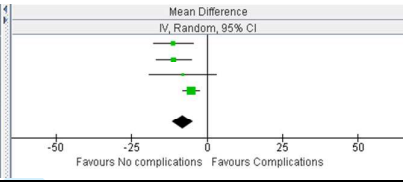
SF physical functioning (SF PF)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	67.9	28.9	52	78.3	23.1	402	24.2%	-10.40 [-18.57, -2.23]
10-Rea	50.3	9.66	23	53.37	7.03	83	61.6%	-3.07 [-7.30, 1.16]
27-Polese	79	22.5543	22	85	33.6097	125	14.2%	-6.00 [-17.11, 5.11]
Total (95% CI)			97			610	100.0%	-5.26 [-9.67, -0.85]
Heterogeneity: Tau² = 3.58; Chi² = 2.49, df = 2 (P = 0.29); I² = 20%								
Test for overall effect: Z = 2.34 (P = 0.02)								



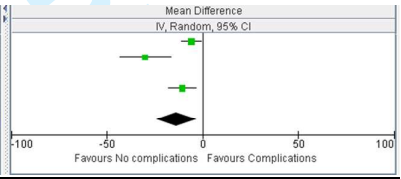
SF vitality (SF VT)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	50.2	23	52	61.3	21.7	402	20.2%	-11.10 [-17.70, -4.50]
10-Rea	43.56	13.33	23	54.53	8.69	83	24.2%	-10.97 [-16.73, -5.21]
27-Polese	68	22.5543	22	76	33.6097	125	8.9%	-8.00 [-19.11, 3.11]
28-Kement	46.42	2.19	9	51.67	5.34	19	46.7%	-5.25 [-8.05, -2.45]
Total (95% CI)			106			629	100.0%	-8.06 [-11.63, -4.49]
Heterogeneity: Tau² = 5.07; Chi² = 4.84, df = 3 (P = 0.18); I² = 38%								
Test for overall effect: Z = 4.43 (P < 0.00001)								



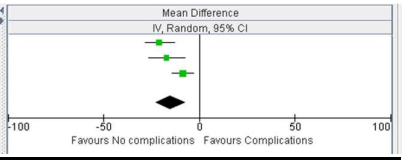
SF general health (SF GH)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
☑ 10-Rea	49.99	11.57	23	55.88	7.35	83	38.8%	-5.89 [-10.88, -0.90]
☑ 27-Polese	51	27.0651	22	81	39.5408	125	25.6%	-30.00 [-43.26, -16.74]
☐ 28-Kement	49.22	3.15	9	53.43	3.6	19	0.0%	-4.21 [-6.83, -1.59]
☑ 30-Gjeilo	61.1	25.3	52	71.6	20.9	402	35.6%	-10.50 [-17.67, -3.33]
Total (95% CI)			97			610	100.0%	-13.71 [-24.40, -3.02]
Heterogeneity: Tau² = 70.26; Chi² = 11.26, df = 2 (P = 0.004); I² = 82%								
Test for overall effect: Z = 2.51 (P = 0.01)								



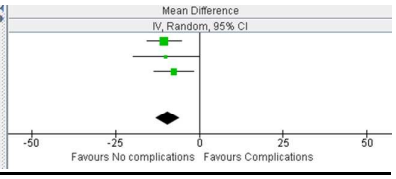
SF bodily pain (SF BP)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
10-Rea	44.99	12.92	23	53.66	10.47	83	38.5%	-8.67 [-14.41, -2.93]
27-Polese	77	22.5545	22	94	11.6697	125	28.3%	-17.00 [-26.64, -7.36]
30-Gjeilo	58.2	26.9	52	79	24.8	402	33.2%	-20.80 [-28.50, -13.10]
Total (95% CI)			97			610	100.0%	-15.05 [-23.04, -7.07]
Heterogeneity: Tau² = 34.52; Chi² = 6.66, df = 2 (P = 0.04); I² = 70%								
Test for overall effect: Z = 3.70 (P = 0.0002)								



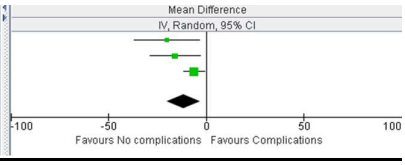
SF mental health (SF MH)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	71.6	18.4	52	82.1	15.1	402	48.9%	-10.50 [-15.71, -5.29]
27-Polese	67	20.2988	22	77	28.2435	125	13.8%	-10.00 [-19.82, -0.18]
10-Rea	44.25	13.92	23	51.79	8.4	83	37.3%	-7.54 [-13.51, -1.57]
28-Kement	47.39	2.99	9	48.99	3.03	19	0.0%	-1.60 [-3.98, 0.78]
Total (95% CI)			97			610	100.0%	-9.33 [-12.97, -5.68]
Heterogeneity: Tau² = 0.00; Chi² = 0.56, df = 2 (P = 0.76); I² = 0%								
Test for overall effect: Z = 5.01 (P < 0.00001)								



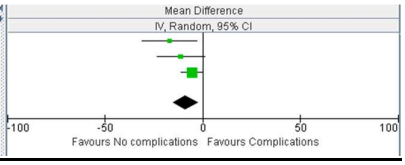
SF role physical (SF RP)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	40.2	44.7	52	56.2	42.8	402	27.5%	-16.00 [-28.85, -3.15]
10-Rea	47.02	13.05	23	53.14	7.46	83	52.9%	-6.12 [-11.69, -0.55]
27-Polese	68	33.8314	22	88	50.8382	125	19.6%	-20.00 [-36.71, -3.29]
Total (95% CI)			97			610	100.0%	-11.56 [-20.33, -2.78]
Heterogeneity: Tau² = 29.85; Chi² = 3.82, df = 2 (P = 0.15); I² = 48%								
Test for overall effect: Z = 2.58 (P = 0.010)								



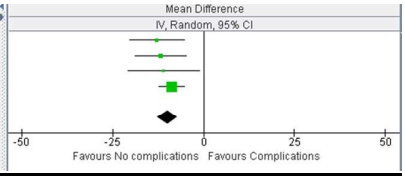
SF role emotional (SF RE)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	62.07	43.05	52	73.2	38	402	21.8%	-11.13 [-23.41, 1.15]
27-Polese	75	29.3207	22	92	39.5408	125	17.4%	-17.00 [-31.08, -2.92]
10-Rea	45.26	12.89	23	50.59	8.81	83	60.8%	-5.33 [-10.93, 0.27]
Total (95% CI)			97			610	100.0%	-8.63 [-15.00, -2.25]
Heterogeneity: Tau² = 9.24; Chi² = 2.66, df = 2 (P = 0.26); I² = 25%								
Test for overall effect: Z = 2.65 (P = 0.008)								



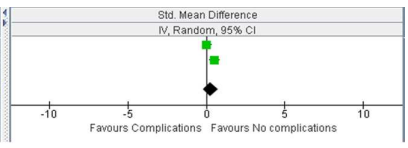
SF social functioning (SF SF)

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Mean Difference IV, Random, 95% CI
30-Gjeilo	74	26.8	52	86.8	20.2	402	13.9%	-12.80 [-20.35, -5.25]
10-Rea	40.14	16.56	23	51.91	9.53	83	15.8%	-11.77 [-18.84, -4.70]
27-Polese	82	20.2988	22	93	28.2435	125	8.2%	-11.00 [-20.82, -1.18]
28-Kement	48.1	5.4	9	56.81	1.21	19	62.1%	-8.71 [-12.28, -5.14]
Total (95% CI)			106			629	100.0%	-9.95 [-12.76, -7.14]
Heterogeneity: Tau² = 0.00; Chi² = 1.31, df = 3 (P = 0.73); I² = 0%								
Test for overall effect: Z = 6.93 (P < 0.00001)								



Anxiety

Study or Subgroup	Complications Mean	Complications SD	Complications Total	No complications Mean	No complications SD	No complications Total	Weight	Std. Mean Difference IV, Random, 95% CI
18-Kalliomaki	9.18	8.36	56	8.98	6.46	170	49.7%	0.03 [-0.27, 0.33]
44-Tully	4.08	3.45	92	2.56	2.27	92	50.3%	0.52 [0.22, 0.81]
Total (95% CI)			148			262	100.0%	0.27 [-0.21, 0.75]
Heterogeneity: Tau² = 0.10; Chi² = 5.19, df = 1 (P = 0.02); I² = 81%								
Test for overall effect: Z = 1.12 (P = 0.26)								



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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Not available
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Suppl. Materials
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7-8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Suppl. Materials

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8-9

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9 & Fig 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Tables 1-4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Tables 1-3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Suppl. Materials and Tables 1-3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Suppl. Materials
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17-18

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	18

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

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Primary Subject Heading:	Surgery
Secondary Subject Heading:	Mental health, Patient-centred medicine
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Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

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Abstract

Objective: Surgical complications may affect patients psychologically due to challenges such as prolonged recovery or long-lasting disability. Psychological distress could further delay patients' recovery as stress delays wound healing and compromises immunity. This review investigates whether surgical complications adversely affect patients' post-operative wellbeing and the duration of this impact.

Methods: The primary data sources were 'PsychINFO', 'Embase' and 'MEDLINE' through OvidSP (year 2000 to May 2012). The reference lists of eligible articles were also reviewed. Studies were eligible if they measured the association of surgical complications after cardiac, thoracic, gastro-intestinal or vascular surgery with adult patients' post-operative psychosocial wellbeing using validated tools or psychological assessment. 13,605 articles were identified. Two researchers independently extracted information from the included articles on study aims, participants' characteristics, study designs, surgical procedures, surgical complications, wellbeing outcomes and findings. The studies were synthesised qualitatively. Supplementary meta-analyses of the impact of surgical complications on patients' wellbeing were also conducted.

Results: 50 studies were included. Two thirds of the studies found that patients who suffered surgical complications had significantly lower levels of post-operative psychosocial wellbeing even after controlling for patients' pre-operative wellbeing, clinical and demographic factors. There were significant and clinically meaningful differences between patients with complications and patients without on aspects of quality of life including 'problems with daily activities due to emotional problems' (p<.01), 'interference with social activities due to physical and emotional problems' (p<.001), and 'feelings of nervousness and depression' (p<.001). Half of the studies with significant findings reported significant adverse effects of complications on patients' wellbeing at 12 months (or more) post-surgery.

Conclusions: Surgical complications are a significant independent predictor of patients' impaired post-operative psychosocial wellbeing and these effects may remain for a long time post-surgery. The results highlight the critical importance of attending to patients' psychological needs in the aftermath of complex surgery.

Strengths and weaknesses of this study

- This is, to our knowledge, the first systematic review of the literature assessing the impact of surgical complications on patients' psychosocial wellbeing.
- The validity of the findings is reinforced by the fact that only studies that used validated self-report measures for the assessment of patients' wellbeing were included in the review, as well as by the use of a very comprehensive search strategy for the identification of relevant literature.
- Caution should be taken when interpreting these findings to other specialties as the review was limited in four surgical specialties.
- A limitation of this review was the very small number of studies with sufficient data for quantitative synthesis, which did not also permit certain types of sensitivity analyses such as by surgical specialty or type of surgery.

Introduction

Surgical complications pose significant challenges for surgical patients. Complications may vary from very minor events that can be resolved relatively quickly without the need for pharmacological treatment or other intervention, to more serious events which can be life-threatening, require multiple interventions (e.g. return to theatre), delay patient's discharge and may lead to multi-organ failure or even death. [1] A recent review of the literature found that post-operative complications contribute to increased mortality, length of stay and an increased level of care at discharge. [2]

Other than the complications' impact on patients' post-operative recovery, they may also affect patients psychologically. They may contribute to the development of severe psychological distress such as depression or anxiety due to the challenges that are inherent to them in terms of prolonged recovery or long-lasting disability (e.g. severe post-operative pain, permanent disfigurement). An early study found that patients who experienced serious adverse events after surgery reported higher levels of distress than people who had experienced serious accidents or bereavements and psychosocial adjustment worse than in patients with serious medical conditions. [3] Moreover, the authors of an interview study on patients' experiences of cardio-thoracic surgery reported that a small number of patients who had a long and complicated post-operative hospital stay expressed intense feelings of hopelessness and depression. [4] Psychological distress resulting from the experience of surgical complications could further delay patients' recovery from surgery as increased levels of stress delay wound healing [5, 6] and compromise immunity. [7-9]

This review aims to critically review and synthesize the existing literature on the psychosocial impact of surgical complications on adult surgical patients and to estimate the types and duration of this impact. For this purpose, quantitative studies which assessed the association of surgical complications with adult patients' psycho-social wellbeing post-surgery were reviewed. Our hypothesis was that the occurrence of surgical complications adversely affects patients' psychosocial wellbeing. More specifically, the research questions that this systematic review aims to answer are:

- Do surgical complications impact on patients' psychosocial wellbeing?
- Is the psychosocial impact transitory or long-lasting?

Methods

Search strategy

The following databases were searched through OvidSP: 'PsychINFO' (1967 to 25th May 2012), 'Embase' (1947 to 25th May 2012) and 'Medline' (1948 to 25th May 2012). A search strategy was developed specific to each database. The three facets of the search strategy were:

A. Adult surgical patients

Terms such as patients, inpatients, outpatients, men, women were used for this facet.

B. Patient psychosocial outcomes

Key psychosocial outcomes that are commonly used to assess patients' wellbeing include anxiety, depression and quality of life. Terms for post-traumatic stress were also included due to the relevance of this psychological outcome in situations where a person is exposed to extreme stress. [10] Generic terms such as wellbeing and emotions were also used.

C. Surgical complications

Surgical complications were defined as any adverse event in relation to the surgical procedure including search terms for complications (e.g. adverse events, untoward incidents) and terms about the surgical setting (e.g. surgical, post-operative).

Each of the facets was expanded into a list of search terms truncated and combined with each other using Boolean operators, and also by mapping those to their relevant MeSH headings and sub-

headings in each database (through explosion of each MeSH heading). The search was restricted to titles and abstracts, and the results were limited to studies that used human participants and were written in English. The search strategies are presented in supplementary material 1. Database searching was complemented by reviewing the reference lists of eligible articles.

Eligibility criteria

Studies were included in the review if they met the following criteria:

- Any quantitative study that measured the association of surgical complications with adult patients' psychosocial wellbeing after surgery, either as a primary or secondary aim. Specific types of complications were not pre-defined as this review was interested in the impact of any surgical complications on patients' wellbeing. Psychosocial wellbeing was assessed with validated self-report tools or psychological assessment.
- Studies of surgical complications after cardiac, thoracic, gastro-intestinal or vascular surgery where complications are more likely to occur. [11] Studies of neuropsychological complications (e.g. delirium) and studies of transplantation procedures were excluded.

Conference proceedings, non-empirical data and articles that were published before the year 2000 or with the majority of their participants recruited before the year 2000 were excluded. This current approach in the selection of literature was expected to reduce bias resulting from studies of out-dated surgical practices.

Study selection

A total of 50% of the abstracts were reviewed independently by two researchers (AP and RD) and disagreements were resolved by consensus. The remaining half of the retrieved abstracts were

reviewed by the primary researcher (AP) based on the consensus that was achieved for the first half. After excluding ineligible articles at abstract and title level, the remaining articles were assessed in full text. The eligibility criteria were applied again on each article. Reasons for exclusion were coded. Articles for which there was uncertainty were discussed between the primary researcher (AP), a researcher with background in psychology (RD) and a researcher with background in surgery (AA). Any disagreements were resolved by consensus.

Data extraction and quality assessment

The primary researcher (AP) and a researcher with a background in surgery (AA) independently extracted data from 20 articles, which they reviewed for any disagreements. Disagreements were resolved by consensus or referral to a third senior researcher (OF). Data were extracted from the remaining articles by the primary researcher and were later checked by the second reviewer (AA). A total of 10 authors were contacted by email to provide information that was not included in the manuscript. Three articles were excluded from the analysis as their authors did not respond to our requests for further information. Information was extracted from each article on study aims, participants' characteristics, study design, surgical procedure, surgical complications (i.e. types, definitions and method of recording, where available), wellbeing outcomes (including scales and time-points of measurement) and relevant findings.

The quality of the included studies was assessed with the Newcastle Ottawa scales (NOS). [12] The scales were modified in order to reflect the research questions of the review and to also incorporate the assessment of cross-sectional studies.

Data synthesis

The included studies were first synthesised narratively. In order to quantify the degree of the impact of surgical complications on patients' wellbeing quantitative procedures were also used. A meta-analysis was conducted on each extracted wellbeing outcome using Review Manager (version 5.2).[13] I^2 was used to calculate the heterogeneity present in the meta-analyses. Heterogeneity was considered low when it was below 25% and high above 50%. [14] A random effects approach was chosen, as a degree of heterogeneity between studies should always be assumed in social sciences. [15] Where multiple assessments were conducted in one single study, only the one furthest from the participants' surgery was included in the meta-analysis.

Results

18,585 articles were retrieved in total across the three databases. After removing duplicate references, a total of 13,605 papers were reviewed at abstract and title level. 994 articles remained to be assessed in full text. A total of 51 articles (50 studies) were eligible for inclusion in the final stage of the review (see Figure 1).

-Figure 1 -

Study characteristics

Details of the included studies are presented in Tables 1-3. A total of 28 studies were conducted in Europe, 14 in the US, three in Australia, two in Turkey, one in Egypt, one in Japan, and one in Taiwan. There were 29 studies in gastro-intestinal, [16-44] 17 in cardio-thoracic, [45-62] and four in vascular surgery. [63-66] The majority of the included studies (40 studies) assessed major procedures. The most common indications for surgery were heart conditions, followed by different types of cancer.

Twenty-three studies examined the association between surgical complications and patients' wellbeing as a primary research aim. [17, 19, 28, 30-38, 43, 47, 48, 50-53, 55, 62, 64, 66] The remaining examined this relationship as part of an exploration of the association of different clinical factors with patients' postoperative wellbeing. The majority of the studies were cohort studies. There were four case-control and 20 cross-sectional studies.

Quality of life was the main psychosocial outcome. Three studies assessed anxiety,[30, 40, 62] four studies assessed depression,[31, 41, 49, 62] and one study assessed mood states.[41] No other psychosocial outcomes were studied. The SF-36 (and its associated versions, i.e. SF-12, SF-20) was the most commonly used scale for the assessment of quality of life.[18, 25-31, 36-38, 42, 43, 45, 46, 48, 51-55, 57-59, 61, 63]

The vast majority of the studies used a-priori definitions of complications. For example, Bloemen et al. recorded only severe complications based on a grading system of surgical operations. [19] Dasgupta et al., also recorded major complications which were defined as "those associated with systemic illness requiring transfer to a higher level of care or requiring relaparotomy, or complications needing interventional radiology". [23] Others used pre-defined categories of complications such as infections, respiratory complications, chronic postoperative pain or perioperative myocardial infarctions. A total of 14 studies did not define or describe the complications that were recorded. The majority of the studies recorded a range of post-operative complications. 18 studies focused on a single category of complications (e.g. anastomotic leaks, peri-operative myocardial infarctions, wound complications, atrial fibrillation). Complications were mostly recorded through medical records review, clinical examinations and review of administrative databases.

Study quality varied. The scores of the included studies ranged from 2 to 8, with a mean score of 5.9. Points were deducted for the following reasons: lack of information on how complications were defined or on the methods that were used for their recording,[16-18, 21-23, 25, 29, 35, 37, 40-42, 46, 51, 55-57, 61, 63] lack of information on response rates,[16, 21, 22, 25-27, 29, 37, 40, 50, 52, 54, 55, 57, 60, 61] patients' baseline wellbeing was not measured or controlled for in the analysis, [17, 19, 20, 25, 27, 30-36, 38-40, 43-45, 47, 49, 53, 63] and

demographic or clinical factors were not controlled for. [20, 25, 27, 31, 32, 34, 40, 43, 45, 51, 56, 61, 63] Only 7 studies scored exceptionally low (i.e. below 4).

-Tables 1,2,3-

The impact of surgical complications on patients' wellbeing

The majority of studies (n=32) found that patients who suffered surgical complications had significantly lower post-operative wellbeing than patients with uncomplicated recovery.[16-20, 22, 24, 25, 28, 30, 31, 33, 35-37, 39, 41-48, 50-52, 54, 57, 60, 62, 65] This was the case not only after major surgical procedures but also after relatively minor operations such as hernia repairs. [30, 18, 28, 31, 43] The vast majority (n=25, 78%,) were of high quality (i.e. quality assessment score greater than 6 out of 8). For instance, more than half of the studies with significant findings had measured and controlled for patients' baseline wellbeing (n=18) [16, 18, 22, 24, 28, 37, 41, 42, 46, 48, 50-52, 54, 57, 60, 62, 65] and used multivariate analyses (n=21), [16, 18, 19, 22, 24, 25, 28, 35, 37, 39, 41, 42, 44, 46, 47, 50, 52, 54, 60, 62, 65] suggesting that complications remained a significant independent predictor of patients' postoperative wellbeing even after controlling for a range of clinical and demographic factors. Domains of patients' wellbeing that were significantly negatively affected by surgical complications included physical, emotional, and social aspects of patients' quality of life as well as anxiety and depression levels (see Table 4). Complications that were found to be significantly associated with low levels of patient wellbeing included both major events such as perioperative myocardial infarctions after CABG, [50] severe incontinence after internal sphincterectomy [31] or graft-related events after vascular surgery, [65] and minor complications such as wound infections after hepatic resection, [20] or new cardiac arrhythmias after CABG. [54] The complications that were significantly associated with patients' post-operative wellbeing are presented in Tables 1-3.

Six studies reported a confounding association between surgical complications and patients' wellbeing (i.e. complications were significantly associated with worse wellbeing only under certain

conditions) [21, 32, 40] or complications were significantly associated with patients' wellbeing at univariate but not at multivariate analysis. [49, 59, 64] A total of 12 studies did not find a significant association of surgical complications with patients' postoperative wellbeing. [23, 26, 27, 29, 34, 38, 53, 55, 56, 61, 63, 66] The majority of them (n=7) scored below 6 on quality assessment. For example, four studies suffered from very small sample sizes. [26, 27, 34, 38]

-Table 4 -

Meta-analyses

A series of supplementary meta-analyses were conducted on each extracted outcome (i.e. quality of life, anxiety, depression). For a meta-analysis on Quality of life only studies that used the SF-scales were considered, as they were the most commonly used quality of life assessment tools. There were three studies with sufficient data on the physical and mental quality of life component scores, [28, 31, 45] and three studies with data on 'physical functioning' (i.e. limitations in performing physical activities), 'bodily pain' (i.e. limitations due to pain), 'role -physical ' (i.e. problems with daily activities as a result of physical health), and 'role -emotional' (i.e. problems with daily activities as a result of emotional health), [36, 37, 48] Moreover, there were four studies with sufficient data on 'general health' (i.e. evaluations of overall health), 'social role functioning' (i.e. interference with normal social activities due to physical and emotional problems), 'mental health' (i.e. feelings of nervousness and depression), and 'vitality' (i.e. feeling tired). [31, 36, 37, 48] The pooled mean differences between the two groups were significant for each quality of life sub-domain. The pooled differences were more than 5 points (on a scale from 0 to 100) for most of the sub-domains, indicating clinically meaningful [67] adverse effects of complications on the different quality of life domains (see supplementary materials). Two studies provided sufficient data for a meta-analysis on anxiety. [30, 62] The pooled SMD was not significant. A meta-analysis on depression was not possible as only one study provided sufficient data. [30]

For a more detailed report of the meta-analyses see supplementary materials 2-4.

The duration of the impact of surgical complications on patients' wellbeing

Eighteen out of the 38 studies which reported significant associations (including the six studies which reported confounding findings) found a significant relationship of the presence of post-operative complications with lower levels of wellbeing at 12 months post-surgery or later. [16, 19-22, 25, 28, 30-33, 36, 37, 47, 48, 50, 51, 65] Twenty studies reported a significant association of complications with lower levels of patient wellbeing less than 12 months post-surgery. [17, 18, 24, 35, 39-46, 49, 52, 54, 57, 59, 60, 62, 64]

Discussion

This is, to our knowledge, the first systematic review of the literature assessing the impact of surgical complications on patients' psychosocial wellbeing. In line with our hypothesis, two thirds of the included studies found a significant negative association between the occurrence of surgical complications and patients' postoperative wellbeing. The vast majority of those studies were of high quality. For instance, more than half of the studies with significant findings found that complications were an independent predictor of patients' postoperative wellbeing after controlling for pre-existing differences on patients' wellbeing, clinical and demographic variables.

Significant associations were reported between surgical complications and lower scores not only on physical but also on emotional and social dimensions of the various quality of life measures. A meta-analysis of the studies that used the SF-scales confirmed the existence of significant and clinically meaningful adverse effects of complications on various domains of patients' quality of life including patients' mental health, social functioning and problems with daily activities as a result of emotional problems. These findings confirm earlier preliminary findings on the psychological burden that surgical adverse events often cause on patients. [3, 4] Surgical complications were also significantly associated with higher post-operative anxiety and depression in individual studies, even though a

population effect could not be shown in meta-analysis due to the very small number of studies that assessed anxiety and depression in relation to surgical complications. Despite the fact that quality of life is a useful screening outcome offering a general picture of a person's physical health and psychological state, [68] future studies on the psychosocial impact of surgical complications should focus more on outcomes such as anxiety and depression as they offer a more accurate picture of a person's psychological wellbeing. Highly relevant psychological outcomes such as post-traumatic stress that were not assessed in any of the included studies would also be of relevance for future research in this area.

Complications that were found to significantly contribute to patients' low post-operative wellbeing ranged from severe adverse events such as anastomotic leaks after gastro-intestinal surgery or perioperative myocardial infarctions after cardiac surgery to relatively minor complications such as wound infections or atrial fibrillation. It is not therefore only severe post-operative events that cause emotional distress and disruption during patients' convalescence but also less serious complications. Wound complications for instance may affect patients' satisfaction with their body image which may in turn affect their quality of life and psychological wellbeing. [69] Moreover, this finding shows that the severity of complications as judged by clinicians does not always relate to how patients experience complications or how severely they are affected by them. Similarly, complications were found to be negatively associated with patients' post-operative wellbeing not only after major surgical procedures but also after relatively minor operations, [30, 18, 28, 31, 43] which suggests a potential independence of the magnitude of initial surgery with the development of significant effect of complications on patients' wellbeing. Further research on how complications affect patients' wellbeing after different types of surgery will help elucidate the role of this factor.

A considerable number of studies also found a significant negative contribution of surgical complications to patients' psychosocial wellbeing more than a year post-operatively, suggesting that patients may suffer psychologically due to the experience of surgical complications for an extensive

period of time after their surgery. The above findings hold important implications for surgical patients' recovery. There is growing evidence on the role of psychological stress in compromising the function of the immune system and slowing down wound healing. [7-9] The emotional distress that surgical complications inflict on patients is likely to further compromise their recovery in almost a reciprocal cycle of distress and decreased immune function. The exact relationships between the occurrence of surgical complications, psychological distress and speed of recovery warrant further investigation.

It is noteworthy that a smaller number of studies did not find a significant association between complications and patients' postoperative wellbeing or found significant univariate associations which were not replicated in multivariate models. Even in studies showing a significant impact there will be many patients who largely maintain their psychological health and quality of life in the aftermath of complications. Other than clinical factors, factors such as patients' ways of coping with stress, their appraisals of surgery and their condition as well as their perceptions of support from their loved ones and the healthcare professionals may also explain under which conditions complications affect patients' psychosocial wellbeing, as suggested by wider literature on patients' adjustment after surgical treatment. [70- 72] The contribution of psychological factors in ameliorating the psychological impact of surgical complications needs to be further explored.

Overall the quality of the included studies was good as indicated by their relatively high quality assessment scores and the small number of studies that scored exceptionally low. A substantial number of studies with significant findings accounted not only for patients' pre-operative wellbeing but also for a host of other clinical and demographic factors in multivariate analyses confirming that surgical complications were an independent predictor of low levels of postoperative wellbeing above and beyond any pre-existing differences. The validity of the findings is also reinforced by the fact that all the included studies used validated self-report measures for the assessment of patients'

wellbeing, as well as by the use of a very comprehensive search strategy for the identification of relevant literature.

Limitations

A few caveats should be borne in mind when interpreting the above findings. Firstly, even though the majority of the included studies used predefined lists or definitions of complications one third of them did not define or describe the complications that were recorded, nor did they explain their methods of complications recording. Moreover, almost one third of the studies did not describe their response rates, which does not permit inferences about the representativeness of their samples. With regards to the methodology of the systematic review, studies that were published before the year 2000 or with the majority of patients recruited before the year 2000 were excluded. However, limiting this review to literature that was published in the last decade is more reflective of current surgical practices and their associated complications. Caution should also be taken when interpreting these findings to other specialties as the clinical setting in which complications occur may affect their impact on patients' wellbeing. Another limitation was the very small number of studies with sufficient data for quantitative synthesis and the difficulty of synthesising data from different quality of life measures, which resulted in restricting the meta-analyses on data collected only with the SF scales. The small number of studies with available data did not also permit certain types of sensitivity analyses such as by surgical specialty, type of surgery (i.e. minor versus major surgery) or underlying disease (e.g. cancer versus other conditions). These factors may be significant determinants of the extent to which complications negatively impact on patients' post-operative wellbeing. Future studies on the association of surgical complications with outcomes such as anxiety, depression and post-traumatic stress, other than allowing a more accurate investigation of the complications' psychological impact, would also permit fuller meta-analyses of these effects. Lastly,

there is always the potential for publication bias where studies with significant results and big effect sizes are more easily published. [73-75]

Implications of findings

The results highlight the importance of considering patients' psychological needs in the aftermath of complicated surgical recovery. Surgical and nursing staff need to be aware of the challenges of surgical complications for patients' wellbeing and ensure that their psychological needs are not neglected. Screening patients who suffer post-operative complications for symptoms of psychological distress could help clinical staff identify those patients who need psychological support. Facilitating patients' access to psychological support during their hospital stay and arrangements for follow-up support could also be of great value for patients' post-operative wellbeing. For example, early referral to psychological services and early psychological interventions could prevent long-term psychological distress and may also mitigate the negative effects of stress on patients' recovery. Primary care practitioners and carers need also to be aware of the psychological burden that surgical complications impose on patients' lives in order to recognise their distress in time and to provide the support that patients need.

Conclusions

This is the first systematic review of the literature on the impact of surgical complications on patients' psychosocial wellbeing. The findings of this review strongly suggest that surgical complications are a significant independent predictor of patients' impaired post-operative psychosocial wellbeing often for a very long time post-surgery. It is not only major complications that may compromise patients' psychosocial wellbeing but also relatively minor adverse events,

which implies that the clinical severity of complications does not always indicate how seriously patients will be affected by them. Patients who experience surgical complications report lower levels of different aspects of quality of life than patients with uncomplicated recovery, often more than a year after their operation. The ways in which complications are managed (e.g. reoperation versus conservative management), the type of surgery (e.g. minor versus major), the underlying disease (e.g. cancer versus other conditions), psychological mechanisms (e.g. patients' perceptions of support, illness perceptions, coping strategies) or cultural influences may be key factors that moderate the impact of surgical complications on patients' psychosocial wellbeing. Future research should try to disentangle the contribution of the above factors on the impact of surgical complications on patients' post-operative wellbeing. Lastly, future studies should try to understand the impact of surgical complications on psychological outcomes such as anxiety, depression and traumatic stress and how to better support patients who experience a complicated post-operative recovery.

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Data sharing: No additional unpublished data

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Table 1: Key characteristics of gastro-intestinal surgery studies (n=29)

First author's name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of surgical complications with patients' wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Anthony	2003	US	Secondary	Nt1=71/? Nt2=63 Nc=16	Colorectal cancer, male patients who underwent open surgical therapy	Observational, cohort, prospective	Open surgical therapy for colorectal cancer	*Morbidity* was defined as any event that resulted in the need for additional therapy or readmission to the hospital within 30 days of initial discharge/Method not specified	Quality of life (QOL)/at time of diagnosis and 12 months after surgery/FACT-C[1]	YES*	Any complications/12 months post- surgery	**6**
Avery	2006	UK	Primary	N=139/162 Nc=37	Patients with esophageal or gastric cancer who underwent upper gastro-intestinal surgical treatment	Observational, cross-sectional	Upper gastro-intestinal surgical treatment for esophageal or gastric cancer	A major complication was defined as reoperation, readmission to the high-dependency or intensive care unit, readmission to the hospital within 30 days of operation, or death within 30 days of operation or later if the patient did not leave the hospital/Method not specified	QOL/39.6days after treatment (range,6–105)/EORTC QLQ-C30[2]	YES	Any complications/39.6 days after treatment (range: 6–105)	**5**
Bitzer	2008	Germany	Secondary	Nt1=151/205 Nt2=130 (86.1%) Nc(complaints)=49 Nc(wound infection)=5 Nc(seroma)=13 Nc(pneumonia)=1 Nc(other)=28	Patients undergoing cholecystectomy	Observational, cohort, prospective	Cholecystectomy	Retrospective list: Any complaint, Wound infection, Seroma, Pneumonia, other complaints/Patient reports	QOL/14 days pre-op, 14 days post-op, and 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**7**
Bloemen	2009	Netherlands	Primary	N=121/170 Nc=33	Rectal cancer patients	Observational, cross-sectional	Surgical treatment for adenocarcinoma of the rectum	Only severe complications were considered: Grade III or IV complications (according to Dindo's model) were defined as severe, whereas absence of complications or Grade I and II complications were defined as absent or mild complications/patient records	QOL/36 (16–51) months post-op /EORTC QLQ-C30 & CR38[3]	YES	Severe post-operative complications/Median of 36 (range, 16–51) months post-surgery	**6**
Bruns	2010	Germany	Secondary	N=96/188 Nc(any morbidity)=30 Nc(wound infections)=10	Patients who underwent curative hepatic resection for malignant or non malignant diseases, disease free at time of assessment	Observational, cross-sectional	Hepatectomy	Surgical (e.g. bile leak or biloma, pneumothorax, wound infection, liver abscess, bleeding, and surgical dehiscence) and medical (e.g. pleural effusion, renal failure, hepatic failure, pneumonia, cardiac insufficiency, and cholangitis)/patient records	QOL/ 3-36 months post-op /SF-12	YES	Wound infections/3-36 months post-surgery	**5**

[1] Functional assessment of cancer therapy questionnaire with the colorectal module
[2] European Organisation for Research and Treatment of Cancer core
[3] European Organisation for Research and Treatment of colorectal cancer

Champault	2006	France	Secondary	Nt1=152/? Nt(4)=139 Nc=(unclear)	Consecutive patients operated on for morbid obesity.	Observational, cohort, prospective	Laparoscopic placement of a gastric band	Retrospective list: pulmonary atelectasis or pneumonia, prolonged ileus, minor wounds problems and urinary retention. Slippage with a peak incidence during the second postoperative year. Band erosion with penetration into the stomach. Access port problems (infection, hematoma, leak, disconnection), bands explanted, associated with erosion, obstruction, immediate intolerance, and recurrent tubing break/Method not specified	QOL/pre-op, 1, 3 months & 2 years post-op/GIQLI[4]	CONFOUNDING*	Band removal for complications such as erosion, slippage, intolerance/2 year post-surgery	**6**
Chang	2010	Taiwan	Secondary	N=102/218 Nc(anastomotic stricture)=12 Nc(gastrojejunal anastomotic ulcer) =9 Nc(upper gastro-intestinal bleeding) =1 N(GORD)=2	Patients undergoing bariatric surgery.	Observational, case-control, longitudinal	Roux-en-Y bypass	Operation related complications, including gastrojejunal anastomotic stricture, gastrojejunal anastomotic ulcer, upper gastro-intestinal bleeding and GORD/Method not specified	QOL/pre-op, 1, 3, 6 and 12 months post-op/WHOQOL-BREF[5]	YES*	Any complications/1, 3, 6, 12 months post-surgery	**5**
Dasgupta	2008	UK	Secondary	Nt1=102/122 Nt2=87 Nt3=80 Nt4=33 Nc=44	Consecutive, patients undergoing liver surgery for liver cancer	Observational, prospective, cohort	Liver resection for hepatic malignancies	Major complications were defined as those associated with systemic illness requiring transfer to a higher level of care (high-dependency or intensive care unit) or requiring relaparotomy, or complications needing interventional radiology/Method not specified	QOL/pre-op, 6, 12, 36-48 months post-op/EORTC QLQ-C30	NO*	N/A	**6**
Delaney	2003	US	Secondary	Nt1=109/109 Nt2=82/109 Nc(any)=19 Nc(major)=9	Patients with Crohn's Disease	Observational, cohort, prospective	Surgery for CD (abdominal perineal, loop or end stoma)	Retrospectively listed complications: anastomotic leak, intraabdominal abscess, bleeding, venous thrombosis, renal failure, and pneumonia, dehydration, intraabdominal abscess, small bowel obstruction and wound infection/Database review	QOL/pre-op & 30 days post-op/CGQL[6]	YES*	Any complications/30 days post-op	**7**
Douma	2011	Netherlands	Secondary	N=296/? Nc=?	296 patients with FAP who had been surgically treated	Observational, cross-sectional	Surgery for familial adenomatous polyposis (FAP)	Surgery-related complications/Self-reports + medical records	QOL/0 to >10 years post-op/SF-36, EORTC-QLQ-C38,Social Functioning subscale of the Dutch version of IBDQ[7]	YES	Any complications/0 to >10 years post-surgery	**2**
Dubernard	2006	France	Secondary	Nt1=58/? Nt2=58 Nc=9	Women with colorectal endometriosis who underwent a segmental colorectal resection	Observational, cohort, prospective	Laparoscopic segmentalcolorectal resection for endometriosis	Retrospectively listed complications: rectovaginal fistulae, vessel injury of the protective colostomy treated by laparoscopic coagulation, uroperitoneum requiring a ureteral stent for 6 weeks and an abscess behind colorectal anastomosis requiring a laparoscopic drainage/Patient observations	QOL/pre & post-op/SF-36	NO*	N/A	**6**
El-Awady	2009	Egypt	Secondary	N=40/? Nc=14	Patients with inguinal hernia	Observational, prospective, cohort	Anterior open Lichtenstein tension free hernioplasty	Postoperative complications: seroma, haematoma, 2ry infection, neuralgia and anaesthesia/patient observations	QOL/pre-op, 3, 6 &12 months post-op/SF-36	NO	N/A	**4**

[4] Gastrointestinal Quality of Life index
[5] World Health Organization Quality of Life – Brief
[6] Cleveland Global Quality of Life
[7] Inflammatory Bowel Disease Questionnaire

Hawn	2006	US	Primary	Nt1=1983/3518 Nt2=1526 (77%) Nt3=1603 (81%) Nc(neuralgia t1)=94 Nc(hematoma t1)=51 Nc(orchitis t1)=13 Nc(recurrence t1)=76 Nc(other t1)=124 Nc(neuralgia t2)=105 Nc(hematoma t2)=55 Nc(orchitis t2)=18 Nc(other t2)=150	Men who received a hernia repair.	Observational, cohort, prospective	Inguinal herniorrhaphy	Complications were summarized by 4 categories: (1) hematoma/seroma, (2) orchitis, (3) neuralgia of the leg or groin, and (4) other. Complications classified as "other" included: (1) early postoperative complications (urinary tract infection, urinary retention, and hematuria); (2) life-threatening complications (respiratory insufficiency, myocardial ischemia, cardiac arrhythmia, intraoperative hypotension, and stroke); and (3) long-term complications (4 weeks or more postoperative)/Patient reports for neuralgia & orchitis + Expert consensus for life-threatening complications	QOL/pre-op, 1 &2 years post-op/SF-36	YES*	Neuralgia, orchitis/2 years post-surgery	**8**
Ince	2011	US	Secondary	Nt1=?/568 Nt2=166 Nc=?	Patients who underwent colorectal resection for benign and malignant diseases.	Observational, cohort, retrospective	Laparoscopic colorectal resection	No reference	QOL/pre-op, 4weeks post-op/SF-36	NO*	N/A	**3**
Kalliomaki	2009	Sweden	Primary	N(total)=184/423 N1=92 (cases) N2=92 (controls)	Patients who had been operated on for groin hernia. Controls matched for age, gender and method of surgical repair were allotted from the group of persons without persisting pain (Grade 1 in IPQ)	Observational, case-control, cross-sectional	Hernia repair	Persistent postoperative pain (patients with pain of Grade 3, i.e. pain that could not be ignored but did not interfere with everyday activities, or higher on IPQ)/Patient reports (Inguinal Pain Questionnaire) & clinical examination	QOL, anxiety, depression/(on average 4.9 years post-op, range > 7 years)/SF-36, HADS[8]	YES	Persistent post-op/Mean of 4.9 years post-surgery	5
Kement	2011	Turkey	Primary	N=253/351 N(incontinence)=28 N(severe incont)=9 N(mild incont)=19	Consecutive patients with chronic anal fissure who underwent open LIS.	Observational, cross-sectional	Open lateral internal sphincterotomy	Anal incontinence/Patient reports: Wexner Incontinence Score system (WIS) + Clinical examination	QOL/23.3 +/- 7.1 months post-op/SF-36	YES	Severe incontinence/23.3 (SD ± 7.1) months post-surgery	**5**
Lim	2006	UK	Primary	N=92/112 Nc(leaks)=23 Nc(clinical leaks)=13 Nc(sub-clinical leaks)=10	Consecutive patients under the care of three consultant surgeons who underwent procedures with LRA	Observational, cross-sectional	Low rectal anastomosis (LRA)	Anastomotic leaks (clinical & subclinical)/Patient observations, CT scans, WCE	QOL/10-18 months post-op/EORTC QOL	CONFOUNDING	Anastomotic leaks/10-18 months post-op	**5**

8 Hospital Anxiety and Depression Scale

Liu	2010	US	Primary	N=679/1308 Nc(early comps/anast)=54 Nc(late comps/anast)=126 Nc(early comps/anast/rectal cancer only)=42 Nc(late comps/ostom/rectal cancer only)=105	Long-term Colorectal Cancer patients	Observational, cross-sectional	Colorectal cancer surgery	-Digestive, skin, genitourinary, surgical, medical, immediate indirect complications -Early complications: those that were first recorded within 30 days of the surgery. Late complications: occurring 31 days after surgery/Patient computerised data	QOL/ 5-15 years post-op/mCOH-QOL-Ostomy[9]	YES	Enterocutaneous fistula for all patients & any late complications for ostomy patients>5 years post-surgery	**6**
Mentes	2006	Turkey	Primary	Nt1=253/302 Nt2=244 Nc(anal fistula/abscess)=3 Nc(FISI>0)=7 Nc(FISI, 0->4, 21, 7)=3	Patients who underwent Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Observational, cohort, prospective	Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Anal Incontinence/Patient examination+ FISI score	QOL/pre-op (admission) & 12 months post-op/GIQLI & FIQL[10]	UNCLEAR (due to small number of patients with complications)	N/A	**6**
Pittman	2008	US	Primary	N=239/322 Nc=56	Veterans with an ostomy after major gastro-intestinal surgery requiring an intestinal stoma	Observational, case-control, cross-sectional	Gastro-intestinal surgery requiring an intestinal stoma	Ostomy complications: skin problems, leakage, and difficulty with adjustment (i.e. leakage, peristomal irritant dermitis, pain, bleeding, stomal necrosis, prolapse, stenosis, herniation, retraction, infection, mucotaneous separation, difficulty adjusting)/Patient reports	QOL/6months post-op/mCOH-QOL-Ostomy	YES	Ostomy complications (skin problems, leakage)/ 6 months post-surgery	**6**
Polese	2012	Italy	Primary	N=147/211 Nc(anastomotic stenoses)=22	Patients who underwent elective left colonic or rectal resection and colorectal anastomosis for neoplastic or inflammatory disease.	Observational, cross-sectional	Left colonic or rectal resection and colorectal anastomosis	Anastomotic stenosis/Clinical examination	QOL/mean 58 (SD ± 31) months post-op/SF-36	YES	Anastomotic stenosis/58 (SD ± 31) months post-surgery	**6**
Rea	2007	US	Primary	Nt1=505/? Nt2=237 Nt3=106 Nc(t2)=41 Nc(t3)=23	Patients who underwent LRYGB by one surgeon for morbid obesity	Observational, cohort, prospective	LRYGB for morbid obesity without conversion to an open procedure.	Postoperative complications requiring intervention/Method not specified	QOL/baseline, 1 & 2 years post-op/SF-36	YES*	Complications requiring intervention/1 & 2 years post-surgery	**6**

9 City of Hope Quality of Life for Ostomates questionnaire
10 Fecal Incontinence Quality of Life Instrument

Riss	2011	Austria	Primary	N1=16/36 (cases) N2=16/? (controls)	Cases: patients operated for rectal cancer and developed anastomotic leak. Controls: Patients operated for rectal cancer at the same time period and had an uneventful postoperative course matched by sex, age (±5 years), type of resection, and neoadjuvant therapy.	Observational, case-control, cross-sectional	Rectal resection for malignancies on overall pelvic organ function	Anastomotic leakage: Defined as grade A (no change in patient's management), grade B (requires active therapeutic intervention but is managed without relaparotomy) and grade C (requires relaparotomy)/Review of the institutional colorectal database and individual chart reviews	QOL/106.8 months post-op (32.4–170.4)/SF-12	NO	N/A	**7**
Rutegard	2008	Sweden	Secondary	N=355/ 446 (79·6 %) Nc=56	Patients diagnosed with an oesophageal or cardia cancer who underwent macroscopically and microscopically radical resection	Observational, cross-sectional	Oesophageal resection	Technical surgical complications, including postoperative bleed exceeding 2000 ml or requiring a reoperation, anastomotic insufficiency, necrosis of the substitute, damage to the recurrent nerve, thoracic duct damage or gastric perforation/Prospective scrutiny of medical and histopathological records, operation charts, extensive study protocol with predefined exposure alternatives	QOL/6months post-op/EORT QLQ-C30, & QLQ-OES1812 [11]	YES	Technical complications/6 months post-surgery	**7**
Scarpa	2009	Italy	Secondary	N=47/? Nc=?	Patients admitted for intestinal surgery for Crohn's Disease	Observational, cross-sectional	Bowel resection through midline laparotomy or with laparoscopic assistance, end ileostomy, stricturoplasty	Medical and surgical complications and need of reoperation (2 anastomotic leaks, 3 intestinal obstructions, 2 intestinal bleeding, and a wound infection were recorded and two re-laparotomies)/Method not specified	QOL/3 months post-op/CGQLI	CONFOUNDING	Any complications/3 months post-surgery	**3**
Sharma	2007	UK	Secondary	Nt1=104 /110 Nt2=92 Nc=41	Consecutive patients with newly diagnosed colorectal cancer scheduled for elective open resection in one hospital trust	Observational, cohort, prospective	Elective resection for colorectal cancer	Wound, urinary tract and chest infections, cardiac and respiratory complications, deep venous thrombosis, pulmonary embolism and complications related to anastomotic breakdown/Method not specified	QOL, anxiety, depression, positive vs. negative affectivity, mood states/pre-op (5-12 days pre-op) & 6-8 weeks post-op/FACT-C, EuroQOL (EQ-5D), HADS, PANAS[12], MRS[13]	YES*	Complications within 30 days of operation/6-8 weeks post-surgery	**6**
Siassi	2009	Germany	Secondary	Nt1=93/113 Nt2,t3=79 Nc=26	Patients undergoing colorectal surgery for benign and malignant disease	Observational, prospective, cohort	Resection of the sigmoid colon or rectum	Postoperative complications (anastomotic leak, wound infection, delayed food intake, fever, and bladder dysfunction)/Method not specified	QOL/pre-op, 3 & 12 months post-op/SF-36 & GLQI[14]	YES*	Any complications/3 months post-surgery	**7**

[11] Oesophageal cancer-specific questionnaire
[12] Positive and negative affect schedule
[13] Mood rating scale
[14] Gastrointestinal Quality of Life Index

Targarona	2004	Spain	Primary	N=37/46 Nc(recurrent hernias)=3	Patients diagnosed with paraesophageal or mixed hiatal hernia (types II, III, and IV) with >50% of the stomach in the chest.	Observational, cross-sectional	Laparoscopic repair of paraesophageal hiatal hernia	Hernia recurrence (any migration of the cardia to chest level or evidence of a new paraesophageal sac)/A barium swallow was given to all patients to rule out an anatomic recurrence. An independent radiologist evaluated all the explorations.	QOL/>=6 months post-op (median, 24; range, 6–50)/SF-36, GDSS[15] and GIQLI	YES	Clinically recurrent hernias/>=6 months post-surgery	**5**
Viklund	2005	Sweden	Secondary	N=100/146 Nc=44	Patients newly diagnosed with a histologically verified adenocarcinoma or squamous-cell carcinoma of the esophagus or adenocarcinoma of the gastric cardia that underwent macroscopically and microscopically radical tumor resection.	Observational, cross-sectional	Esophageal resection surgery for cancer	Anastomotic leakage , infections, respiratory insufficiency, cardiac complications, technical complications, anastomotic strictures, and others (intervention needed to treat embolus, deep venous thrombosis, rupture of the wound, intestinal obstruction, stroke, renal failure, or liver failure)/Patient records	QOL/6 months post-discharge/QLQ-C30 & OES-24[16]	YES	Any complications, anastomotic leakage, infection, respiratory insufficiency, cardiac complications, technical complications/6 months post-discharge	**7**

***Study controlled for patients' preoperative wellbeing**

[15] Glasgow Dyspepsia Severity Score
[16] Symptoms specific to oesophageal cancer

Table 2: Key characteristics of cardio-thoracic surgery studies (n=17)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Deaton	2009	US	Secondary	Nt1= 317/442 Nt2=270 Nc=44% (130)	Patients with documented T2DM undergoing CABG	Observational, cohort, prospective	CABG	Infection of the leg, thorax, sternum, bloodstream or urinary tract; central neurological deficit (stroke or transient ischemia, coma); pneumonia, pulmonary insufficiency with prolonged ventilation or re-intubation, pulmonary embolism; renal failure; arrhythmias requiring treatment; prolonged inotropic support or use of intra-aortic balloon pump; or reoperation for bleeding or tamponade/Patient records	QOL/ 3 months post-op/SF-36	YES	Any complications/3 months post-surgery	**6**
El Baz	2008	Netherlands	Secondary	Nt1=198/256 Nt2=168 Nc=?	Consecutive patients who were scheduled for CABG following a coronary angiography	Observational, cohort, prospective	CABG	Postoperative events such as use of inotropes, atrial arrhythmias, or ventricular arrhythmias, sternal resuturing, re-exploration for bleeding, and time spent on mechanical ventilation/Registry database, medical notes, outpatient notes and intensive therapy unit charts	QOL/pre-op & 6 months post-op/SF-36	YES*	Re-exploration for bleeding and sternal resuturing/6 months post-surgery	**8**
Ferguson	2009	US	Primary	N=124/221 Nc=22	Prospective patients who underwent major lung resection for early stage lung cancer.	Observational, cross-sectional	Major lung resection for early stage lung cancer (lobectomy, bilobectomy, pneumonectomy)	Complications were categorized as pulmonary (pneumonia, prolonged intubation, reintubation, air leak more than 7 days, lobar collapse requiring intervention), cardiovascular (pulmonary embolism, myocardial infarction, new postoperative arrhythmia, need for intravenous inotropic agents), other, and any complication/Administrative database, hospital medical records, office shadow files	QOL/average of 2.6 years post-op (3 months to 6.4 years)/EORTC QLQ-C30, EORTC QLQLC13[17] and DASS-21[18]	YES	Pulmonary complications/2.6 years post-surgery (Range: 3 months-6.4 years)	**6**
Gjeilo	2010	Norway	Primary	Nt1=534/631 Nt2=462 Nt3=465 Nc(t2)=52	Patients undergoing cardiac surgery	Observational, cohort, prospective	Midline sternotomy	Chronic pain (pain arising after surgery and persisting either continuously or intermittently for 3 months or more/BPI (Brief Pain Inventory)	QOL/pre-op, 6 & 12 months post-op/SF-36	YES*	Chronic post-surgical pain/12 months post-surgery	**6**
Hata	2006	Japan	Secondary	N=452/452 Nc=?	Consecutive adult patients who underwent open heart surgery	Observational, cross-sectional	CABG	Postoperative morbidity (minor stroke, infection, pneumonia, haemodialysis, paraplesis)/Patient records	Depression/5-7 days post-op/Interviewed by a psychiatrist and CES-D[19]	CONFOUNDING	Post-operative minor stroke and pneumonia/5-7 days post-surgery	**6**

17 EORTC Lung Cancer Questionnaire
18 Short version of the Depression Anxiety Stress Scales
19 Center for Epidemiological Studies Depression Scale

Jarvinen	2004	Finland	Primary	Nt1=501/1128 Nt2=485 Nc=80	Patients who underwent CABG	Observational, cohort, prospective	CABG [89% via sternotomy incision with cardiopulmonary bypass (CPB; on-pump) and 11% without CPB (off-pump)]	Perioperative myocardial infarctions/Clinical examination + clinical tests (ECGs, echocardiography, laboratory tests)	QOL/pre-op & 12 months post-op/RAND-36	YES*	Perioperative myocardial infarctions /12 months post-surgery	**7**
Jideus	2009	Sweden	Primary	N1=73/84 (cases) N2=42/? (controls)	-Cases: patients who developed sternal wound infection (SWI) after cardiopulmonary bypass. -Controls: patients prior to CABG and evaluated 1 year postoperative and matched for time of the operation, age and sex	Observational, case-control, cross-sectional	Cardiopulmonary bypass	Serious wound infections (SWIs: deep infection involving retrosternal tissue and/or the sternal bone)/Clinical examination	QOL/20 months post-op (range 7-40)/SF-36	YES*	Serious wound infections /20 (Range: 7-40) months post-surgery	**4**
Kinney	2012	US	Primary	N=99 Nt1=120/? Nt2=99 Nc=75	Patients aged 45 to 75 years undergoing elective thoracotomy	Observational, cohort, prospective	Serratus-sparing posterolateral thoracotomy or limited thoracotomy	Chronic post-thoracotomy pain/Leeds Assessment of Neuropathic Symptoms and Signs + self-reports	QOL/pre-op, 3 moths post-op/SF-36	YES*	Chronic post-thoracotomy pain/ 3 months post-surgery	**7**
Landoni	2006	Italy	Primary	N1=22/42 (cases) N2=40/42 (controls)	-Cases: patients who underwent cardiac surgery and developed ARF requiring RRT and left the hospital alive. -Controls: matched controls who did not develop ARF and did not receive RRT.	Observational, case-control, cross-sectional	Cardiac surgery (procedures not specified)	ARF (acute renal failure) requiring RRT (renal replacement therapy)/Administrative database, registry	QOL/23-42 months post-op/SF-36	NO	N/A	**`6**
Le Grande	2006	Australia	Secondary	Nt1=182/444 Nt2=128 Nt3=114 Nc=?	Adults on the waiting list for CABG	Observational, cohort, prospective	CABG	Post-surgical complications such as cardiac arrhythmias, stroke and infections/Medical records	QOL/pre-op, 2 & 6 months post-op/SF-36	YES*	New cardiac arrhythmia post-surgery, atrial fibrillation/ 6 months post-surgery	**7**
Martin	2008	US	Primary	Nt1=836/2,007 Nt2=2.007 Nc=189	Patients undergoing elective open heart surgery	Observational, cohort, prospective	Open heart surgery (133 valve procedure; 620 CABG; 67 CABG plus valve procedure; 15 CABG plus other cardiac procedure; and 1 closure of an atrial septal defect)	Perioperative myocardial infarction, mediastinitis, superficial wound infection, septicemia, permanent stroke, transient ischemic attack, continuous coma, prolonged intubation, ventilator-associated pneumonia, cardiac tamponade, atrial fibrillation, reoperation for bleeding, renal failure, renal failure which required dialysis, and length of stay/Method not specified	QOL/pre-op, 1 year post-op/SF-20	NO*	N/A	**6**
Merkouris	2009	Greece	Secondary	Nt1=63/63 Nt2=59 Nt3=56 Nc=42	All patients over 65 presenting a 1, 2 or 3 vessel disease treated with CABG without concurrent procedures (e.g. valve replacement)	Observational, cohort, prospective	CABG	Retrospective list of complications: Atrial fibrillation, re-exploration for bleeding, low cardiac output syndrome, acute respiratory failure, sternal wound infection, neurological dysfunction, mild problems related to leg incision healing or swelling, chest incision discomfort and medications/Method not specified	QOL/pre-op, 4 & 12 months post-op/MacNew Heart Disease HRQOL questionnaire	NO*	N/A	**5**

Moller	2012	Sweden	Secondary	Nt1=249/? Nt2=213 Nc=?	Prospective patients scheduled for lung surgery for lung cancer	Observational, cohort, prospective	Lung surgery	Complication was defined as any of the following postoperative complications: new onset atrial fibrillation, prolonged air leak (chest tubes in place for more than 5 days), pneumonia, re-intubation, reoperation, or hospital stay of 8 days or more/Method not specified	QOL/pre-op, 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**6**
Myles	2001 & 2006	Australia	Secondary	Nt1=120/125 Nt2=120 (days 1,2,3) Nt3=108 Nt4=94 Nc=69	Adult cardiac surgical patients	Observational, cohort, prospective	Cardiac surgery (specific procedures not specified)	1. Respiratory: postoperative mechanical ventilation for more than 24 h or pneumonia, defined as pulmonary infiltrate with positive microbial cultures; 2. Cardiac: arrhythmia requiring treatment with antiarrhythmic medication or electrical cardioversion reversion; radiologic evidence of pulmonary edema; or myocardial infarction, defined by new Q waves on electrocardiogram or creatine kinase-MB isoenzyme concentration greater than twice normal; 3. Renal: acute renal failure, defined by serum creatinine concentration greater than 200 M; 4. Neurologic: stroke, defined as a new central neurologic deficit; 5. Sepsis: wound infection requiring excision of tissue or antibiotic therapy, or positive microbial culture (other than pneumonia) -Clinical and laboratory tests (microbial cultures, radiologic data, electrocardiograms etc.)	QOL/pre-op, 1 & 3 months, 3 years post-op/SF-36	CONFOUNDING*	Any complications/3 months post-surgery	**8**
Peric	2008	Serbia & Montenegro	Secondary	Nt1=208/? Nt2=192 Nc=60	Consecutive patients who underwent elective CABG	Observational, cohort, prospective	CABG	Retrospective list of complications: low cardiac output (cardiac index lower than 2 L/min/m2), mechanical ventilation longer than 24 hours, reoperation for bleeding, sternal wound infection, perioperative myocardial infarction, pericardial effusion, arrhythmic complications (atrial fibrillation, ventricular tachycardia, ventricular fibrillation), abdominal complications, and other/Observations, ECGs, echocardiography, laboratory tests	QOL/pre-op, 6 months post-op/Nottingham Health Profile Questionnaire (NHP)	YES*	Any complications/6 months post-surgery	**7**
Rodriguez	2008	US	Secondary	Nt1=397/? Nt2=? Nt3=? Nt4=? Nc=23	Patients diagnosed with upper extremity HH treated with TS.	Observational, cohort, prospective	Thoracoscopic sympathectomy for palmar and axillary hyperhidrosis	-Compensatory sweating (CS): Excessive sweating considered abnormal in other parts of the body after TS. -Gustatory sweating: Facial sweating after eating foods -Excessive dryness: Dryness affecting the hands and requiring hydration -Method not specified	QOL/pre-op, discharge, 6 & 12 months post-op/SF-36	NO*	N/A	**3**
Tully	2011	Australia	Primary	Nt1=226/238 Nt2=222 Nc=56	Patients undergoing first-time CABG surgery	Observational, cohort, prospective	CABG	New-onset atrial fibrillation (AF) between the patient's day of admission to the intensive care unit and the median day of discharge (day 5) after CABG during the index hospitalization/ECGs, transthoracic echocardiographs reviewed by technicians and reviewers blinded to patients' psychological distress scores	Anxiety, Depression, Stress/pre-op (mean=2 days, SD=2 days) & post-op (mean=6 days, SD=2 days)/ DASS[20]	YES*	Atrial fibrillation/6 days (SD=2 days) post-surgery	**7**

***Study controlled for patients' preoperative wellbeing**

[20] Depression Anxiety Stress Scales

Table 3: Key characteristics of studies in vascular surgery (n=4)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome & timepoints	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Lohse	2009	Germany	Secondary	N=110/124 Nc=?	Consecutive patients who received a replacement of the dilated ascending aorta.	Observational, cross-sectional	Ascending aorta replacement	Retrospective list: Postoperative bleeding, Myocardial infarction, Stroke, Pneumonia, Respiratory insufficiency, Acute renal dysfunction, Sepsis, Lung fistula/Method not specified	QOL/36.4 ± 15.5 months post-op (11–58 months)/SF-36	NO	N/A	**4**
Nguyen[a]	2007	US & Canada	Primary	Nt1=1296/1404 Nt2=862 Nt3=732 Nc=543	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Lower extremity vein bypass for limb salvage in critical limb ischemia (CLI) patients	Wound complications (WC): patients having infection, necrosis, hematoma-haemorrhage, or seroma-lymphocele at the surgical incision or harvest site within 30 days of the bypass surgery/Adverse events clinical trial documentation with reference to source documentation (hospital notes etc.)	QOL/baseline, 3 & 12 months post-op/VascuQol[21]	CONFOUNDING*	Wound complications/3 months post-surgery	**8**
Nguyen[b]	2006	US & Canada	Secondary	N1=1296/1404 (92.3%) N2=862 (61.4%) N3=732 (52.1%) Nc=?	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Infrainguinal vein grafting for limb salvage in critical limb ischemia (CLI) patients	Graft-related events (GREs): development of a >70% graft stenosis or having undergone a percutaneous or surgical revision or a major amputation/Clinical tests (angiography, ultrasonography etc.), source documentation (hospital notes, discharge notes, operative and procedural notes etc.)	QOL/pre-op, 3 & 12 months post-op/VascuQol	YES*	Graft-related events/12 months post-surgery	**8**
Subramonia	2005	UK	Primary	Nt1=70/70 Nt2=59 Nt3=62 Nc(sensory abnormalities)=25 Nc(bruising at t1)=58 Nc(bruising at t2)=16	Patients with varicose veins, either symptomatic or with skin changes, resulting from incompetence of the LSV as confirmed by handheld Doppler examination or duplex ultrasonography or both and requiring surgical intervention (both day cases and inpatients).	Observational, cohort, prospective	Conventional LSV stripping	-Bruising/Tracing method -Sensory abnormalities, both subjective (paresthesia and dysesthesia) and objective/Patient reports, sensory testing	QOL/pre-op, discharge & 6 weeks post-op/Aberdeen Varicose Vein Questionnaire 2	NO*	N/A	**7**

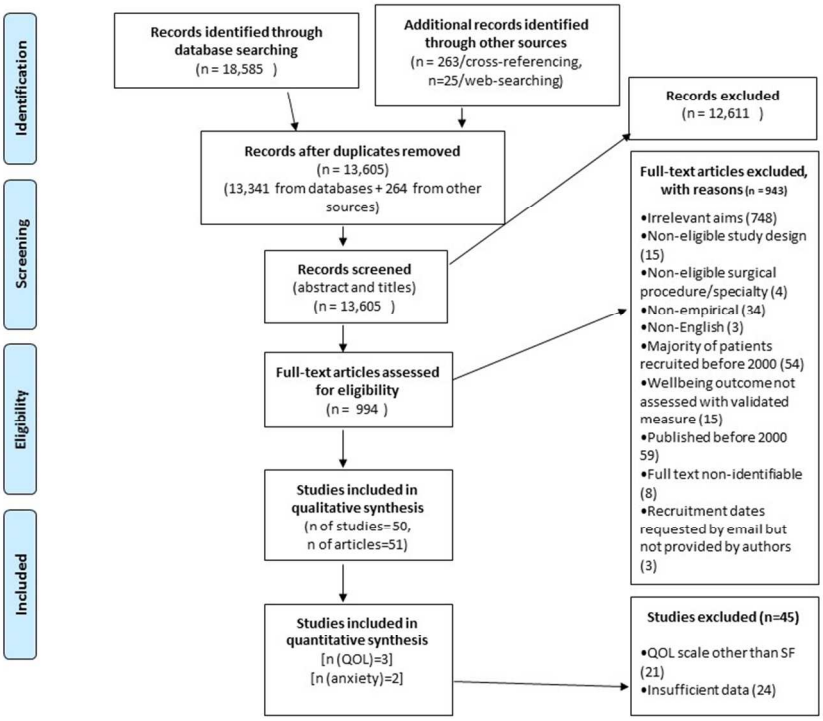
***Study controlled for patients' preoperative wellbein**

[21] A validated instrument assessing pain, symptoms, activities, social life and emotional state in patients with vascular disease

Table 4: Domains of patients' wellbeing that were significantly affected by surgical complications

		Studies																														
Measures		Bruns	Liu	Bloemen	Siassi	Rutegard	Pittman	Sharma	Avery	Le Grande	Nguyen [b]	Viklund	Delaney	Kalliomaki	Hawn	Anthony	Chang	Douma	Kement	Targarona	Peric	El Baz	Deaton	Ferguson	Tully	Gjeilo	Jideus	Kinney	Polese	Rea	Bitzer	Jarvinen	Moller
Short Form scales (e.g. SF-36, SF-12 RAND-36)	Physical-Component	✓			✓					✓					✓			✓	✓				✓									✓	
	Mental Component									✓					✓				✓				✓										
	Physical functioning													✓												✓	✓	✓				✓	✓
	Bodily pain													✓					✓							✓		✓	✓	✓	✓		
	Role physical													✓												✓			✓	✓	✓	✓	
	Role emotional													✓															✓				
	General health													✓					✓							✓	✓		✓	✓		✓	✓
	Mental health													✓								✓				✓			✓	✓			
	Social functioning													✓					✓							✓	✓		✓	✓			
	Vitality													✓					✓			✓				✓		✓		✓			✓
EORTC QLQ-C30+	Physical Functioning			✓		✓			✓	✓		✓						✓						✓									
	Global QOL					✓				✓		✓																					
	Social Functioning								✓																								
	Fatigue			✓		✓																											
	Role functioning					✓			✓																								
	Pain			✓																												
	Weight loss			✓																												

	Dyspnea					✓																										
	Nausea-Vomiting					✓			✓																							
	Coughing						✓																									
	Defecation																		✓													
VascuQOL	Total QOL										✓																					
GIQLI	Total QOL																			✓												
mCOH-QOL	Total QOL		✓																													
	Physical QOL						✓																									
	Social QOL						✓																									
FACT-C	Total QOL														✓																	
	Physical wellbeing							✓							✓																	
	Social wellbeing														✓																	
	Cancer concerns														✓																	
CGQL	Total QOL												✓																			
WHOQOL-BREF	Physical domain															✓																
	Pain & discomfort															✓																
	Activities of daily living															✓																
IBDQ	Social functioning																✓															
NHP	Social isolation																			✓												
	Sleep																			✓												
	Pain																			✓												
HADS & DASS	Anxiety							✓						✓										✓								
	Depression							✓						✓																		
PANAS	Negative affect							✓																								
MRS	Negative mood							✓																								



254x190mm (96 x 96 DPI)

Supplementary materials for manuscript entitled:

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

Supplementary material 1: Search strategies

Embase

1. exp mental stress/
2. exp emotion/
3. exp depression/
4. exp ANXIETY/
5. exp posttraumatic stress disorder/
6. exp "quality of life"/
7. exp wellbeing/
8. 1 or 2 or 3 or 4 or 5 or 6 or 7
9. exp surgery/
10. exp complication/
11. 9 and 10
12. exp surgery/co [Complication]
13. exp perioperative complication/
14. exp peroperative complication/
15. exp postoperative complication/
16. exp preoperative complication/
17. exp surgical error/
18. exp iatrogenic disease/su [surgery]
19. exp anesthesia complication/
20. exp ANESTHESIA/co [Complication]
21. exp anesthesia/
22. exp complication/
23. 21 and 22
24. 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 23
25. exp patient/
26. adult/
27. female/
28. male/
29. 25 or 26 or 27 or 28
30. 8 and 24 and 29
31. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or awareness or iatrogen* or ((adverse or unfavourable or unfavorable or untoward or undesired) adj (outcome*1 or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
32. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or per-operative or peroperative or intra-operative or intraoperative or intra operative or anesth* or anaesth*).ti,ab.
33. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
34. 31 and 32 and 33
35. 30 or 34
36. limit 35 to (human and English language)

MEDLINE

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Stress, Psychological/
9. exp Emotions/
10. exp Depression/
11. exp Anxiety/
12. exp Stress Disorders, Post-Traumatic/
13. exp "Quality of Life"/
14. 8 or 9 or 10 or 11 or 12 or 13
15. exp Medical Errors/
16. exp Postoperative Complications/
17. exp iatrogenic disease/su [surgery]
18. exp Anesthesia/ae, co [Adverse Effects, Complications]
19. 15 or 16 or 17 or 18
20. 14 and 19
21. exp Patients/
22. exp adult/
23. exp women/
24. exp men/
25. exp research subjects/
26. 21 or 22 or 23 or 24 or 25
27. 14 and 19 and 26
28. 7 or 27
29. limit 28 to (English language and humans)

PsycINFO

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Psychological Stress/
9. exp emotions/
10. exp "depression (emotion)"/
11. exp Anxiety/
12. exp posttraumatic stress disorder/
13. exp "Quality of Life"/
14. exp well being/
15. 8 or 9 or 10 or 11 or 12 or 13 or 14
16. exp postsurgical complications/
17. exp patients/
18. exp Human Females/
19. exp human males/
20. 17 or 18 or 19
21. 15 and 16 and 20
22. 7 or 21
23. limit 22 to (human and English language)

Supplementary material 2:

Detailed report of meta-analyses on the impact of complications on patients' psychosocial wellbeing

Quality of life

Due to the different measurement tools that were used for the assessment of QOL as well as the different domains that each tool assesses, a meta-analysis was conducted only on the studies that used the SF-tools. These were the most commonly used tools for the assessment of QoL, they are not condition-specific and they use the same measurement scale. Moreover, all of them yield the same summary scores (i.e. physical and mental). [1] A meta-analysis was conducted on each summary score. The effect sizes are expressed as mean differences (MD) on a scale ranging from 0 to 100.

Only three studies provided sufficient data for a meta-analysis on the SF- physical and mental component scores between patients with complications and patients without complications. [2-4] The pooled mean differences between the two groups indicated significantly lower levels of physical and mental quality of life in patients who suffered complications compared to patients without complications (see eTable1).

The estimates of heterogeneity (I^2) were low (<25%).

Anxiety and Depression

Two studies provided sufficient data for a meta-analysis on anxiety levels. [5, 6] Each study used a different scale, therefore the effect sizes are expressed as standardised mean differences (SMD). The pooled SMD for anxiety was not significant indicating a lack of population effect in terms of the complications' impact on patients' anxiety levels. The estimate of heterogeneity was high (I^2=81%), however a sensitivity analysis by the methodological quality of the included studies did not alter the results. A meta-analysis on depression was not possible as only one study provided sufficient data. [6]

Supplementary material 3

eTable1: Results of meta-analyses on the impact of surgical complications on patient psychosocial outcomes

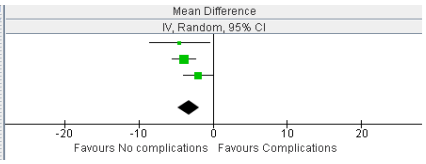
Wellbeing outcome	Sub-score	Comparison	k	N	Z	*P*	MD (SMD/anxiety)	95% CI	I^2
Quality of life (SF-scales)	Physical component	Complications vs.	3	244	4.51	0.00001	-3.28	-4.71, -1.86	20%
		No complications		1638					
	Mental component	Complications vs.	3	244	6.52	0.00001	-3.82	-4.97, -2.67	0%
		No complications		1638					
Anxiety		Complications vs.	2	148	1.12	0.26	0.27	-0.21, 0.75	81%
		No complications		262					

Supplementary material 4:

Forest plots of meta-analyses on the impact of surgical complications on patient psychosocial outcomes

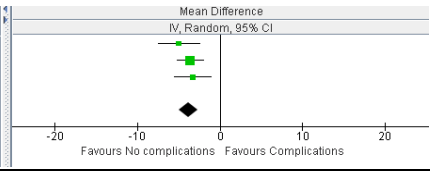
SF Physical summary score (SF PCS)

Study or Subgroup	Complications			No complications			Weight	Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
20-Hawn	41.2	16.0186	105	45.7	52.9351	1479	11.3%	-4.50 [-8.58, -0.42]
28-Kement	53.97	2.22	9	57.91	1.63	19	51.5%	-3.94 [-5.57, -2.31]
39-Deaton	41	9	130	43	8	140	37.2%	-2.00 [-4.04, 0.04]
Total (95% CI)			244			1638	100.0%	-3.28 [-4.71, -1.86]
Heterogeneity: Tau² = 0.34; Chi² = 2.49, df = 2 (P = 0.29); I² = 20%								
Test for overall effect: Z = 4.51 (P < 0.00001)								



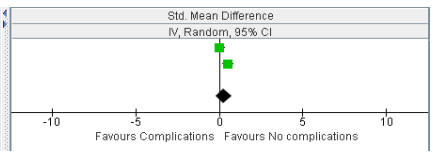
SF Mental summary score (SF MCS)

Study or Subgroup	Complications			No complications			Weight	Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
39-Deaton	43	11	130	48	10	140	20.9%	-5.00 [-7.51, -2.49]
28-Kement	47.17	1.96	9	50.79	2.09	19	52.3%	-3.62 [-5.21, -2.03]
20-Hawn	47.1	10.3346	105	50.4	19.6056	1479	26.9%	-3.30 [-5.51, -1.09]
Total (95% CI)			244			1638	100.0%	-3.82 [-4.97, -2.67]
Heterogeneity: Tau² = 0.00; Chi² = 1.12, df = 2 (P = 0.57); I² = 0%								
Test for overall effect: Z = 6.52 (P < 0.00001)								



Anxiety

Study or Subgroup	Complications			No complications			Weight	Std. Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
18-Kalliomaki	9.18	8.36	56	8.98	6.46	170	49.7%	0.03 [-0.27, 0.33]
44-Tully	4.08	3.45	92	2.56	2.27	92	50.3%	0.52 [0.22, 0.81]
Total (95% CI)			148			262	100.0%	0.27 [-0.21, 0.75]
Heterogeneity: Tau² = 0.10; Chi² = 5.19, df = 1 (P = 0.02); I² = 81%								
Test for overall effect: Z = 1.12 (P = 0.26)								



References

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Not available
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Suppl. Materials
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7-8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Suppl. Materials

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8-9

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9 & Fig 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Tables 1-4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Tables 1-3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Suppl. Materials and Tables 1-3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Suppl. Materials
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17-18

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	18

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

BMJ Open

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

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Primary Subject Heading:	Surgery
Secondary Subject Heading:	Mental health, Patient-centred medicine
Keywords:	SURGERY, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

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Abstract

Objective: Surgical complications may affect patients psychologically due to challenges such as prolonged recovery or long-lasting disability. Psychological distress could further delay patients' recovery as stress delays wound healing and compromises immunity. This review investigates whether surgical complications adversely affect patients' post-operative wellbeing and the duration of this impact.

Methods: The primary data sources were 'PsychINFO', 'Embase' and 'MEDLINE' through OvidSP (year 2000 to May 2012). The reference lists of eligible articles were also reviewed. Studies were eligible if they measured the association of complications after major surgery from four surgical specialties (i.e. cardiac, thoracic, gastro-intestinal and vascular) with adult patients' post-operative psychosocial outcomes using validated tools or psychological assessment. 13,605 articles were identified. Two researchers independently extracted information from the included articles on study aims, participants' characteristics, study design, surgical procedures, surgical complications, psychosocial outcomes and findings. The studies were synthesised narratively (i.e. using text). Supplementary meta-analyses of the impact of surgical complications on psychosocial outcomes were also conducted.

Results: 50 studies were included in the narrative synthesis. Two thirds of the studies found that patients who suffered surgical complications had significantly worse post-operative psychosocial outcomes even after controlling for pre-operative psychosocial outcomes, clinical and demographic factors. Half of the studies with significant findings reported significant adverse effects of complications on patient psychosocial outcomes at 12 months (or more) post-surgery. Three supplementary meta-analyses were completed, one on anxiety (including two studies) and two on physical and mental quality of life (including three studies). The latter indicated statistically significantly lower physical and mental quality of life (p<0.001) for patients who suffered surgical complications.

Conclusions: Surgical complications appear to be a significant and often long-term predictor of patient post-operative psychosocial outcomes. The results highlight the importance of attending to patients' psychological needs in the aftermath of surgical complications.

Strengths and weaknesses of this study

- This is, to our knowledge, the first systematic review of the literature assessing the impact of surgical complications on patients' psychosocial wellbeing.
- The validity of the findings is increased by the fact that only studies that used validated self-report measures for the assessment of patients' wellbeing were included in the review, as well as by the use of a very comprehensive search strategy for the identification of relevant literature.
- Caution should be taken when interpreting these findings to other specialties as the review was limited in four surgical specialties.
- A limitation of this review was the very small number of studies with sufficient data for the quantitative synthesis, which did not also permit certain types of sensitivity analyses such as by surgical specialty or type of surgery.

Introduction

Surgical complications pose significant challenges for surgical patients. Complications may vary from very minor events that can be resolved relatively quickly without the need for pharmacological treatment or other intervention, to more serious events which can be life-threatening, require multiple interventions (e.g. return to theatre), delay patient's discharge and may lead to multi-organ failure or even death. [1] A recent review of the literature found that post-operative complications contribute to increased mortality, length of stay and an increased level of care at discharge. [2]

Other than the complications' impact on patients' post-operative recovery, they may also affect patients psychologically. They may contribute to the experience of psychological distress such as depression or anxiety due to the challenges that are inherent to them in terms of prolonged recovery or long-lasting disability (e.g. severe post-operative pain, permanent disfigurement). An early study found that patients who experienced serious adverse events after surgery reported higher levels of distress than people who had experienced serious accidents or bereavements and psychosocial adjustment worse than in patients with serious medical conditions. [3] Moreover, the authors of an interview study on patients' experiences of cardio-thoracic surgery reported that a small number of patients who had a long and complicated post-operative hospital stay expressed intense feelings of hopelessness and depression. [4] Psychological distress resulting from the experience of surgical complications could further delay patients' recovery from surgery as increased levels of stress delay wound healing [5, 6] and compromise immunity. [7-9]

This review aims to critically review and synthesize the existing literature on the impact of surgical complications on adult surgical patients' psychosocial wellbeing and to estimate the duration of this impact. For the purpose of this review psychosocial wellbeing was defined quite broadly including psychosocial outcomes of relevance to surgery such as anxiety, depression, quality of life and post-traumatic stress. Quantitative studies which assessed the association of surgical complications with adult patients' psycho-social outcomes post-surgery were therefore reviewed. Our hypothesis was

that the occurrence of surgical complications adversely affects patient psychosocial outcomes. Therefore, this systematic review aims to examine whether surgical complications impact adversely on patient psychosocial outcomes and the duration of this impact.

Methods

Search strategy

The following databases were searched through OvidSP: 'PsychINFO' (1967 to 25th May 2012), 'Embase' (1947 to 25th May 2012) and 'Medline' (1948 to 25th May 2012). A search strategy was developed specific to each database. The three facets of the search strategy were:

A. Adult surgical patients

Terms such as patients, inpatients, outpatients, men, women were used for this facet.

B. Patient psychosocial outcomes

A broad definition of psychosocial outcomes was considered for the purposes of this systemic review including search terms for anxiety, depression, quality of life and post-traumatic stress. [10] Two generic terms were also used i.e. wellbeing and emotions. The search did not include specific measures, instead it included terms for the outcomes specified above.

C. Surgical complications

Surgical complications were defined as any adverse event in relation to the surgical procedure including search terms for complications (e.g. adverse events, untoward incidents) and terms about the surgical setting (e.g. surgical, post-operative).

Each of the facets was expanded into a list of search terms truncated and combined with each other using Boolean operators, and also by mapping those to their relevant MeSH headings and sub-

headings in each database (through explosion of each MeSH heading). The search was restricted to titles and abstracts, and the results were limited to studies that used human participants and were written in English. The search strategies are presented in supplementary material 1. Database searching was complemented by reviewing the reference lists of eligible articles.

Eligibility criteria

Studies were included in the review if they met the following criteria:

- Any quantitative study that measured the association of surgical complications with adult patients' psychosocial outcomes after surgery, either as a primary or secondary aim. Studies that measured surgical complications and psychosocial outcomes but not their association were not included as a primary analysis of reported data was beyond the scope of this review. Moreover, specific types of complications were not pre-defined as this review was interested in the impact of any surgical complications on patients' wellbeing.
- Psychosocial outcomes were measured with validated self-report tools or psychological assessment.
- Studies that reported surgical complications after cardiac, thoracic, gastro-intestinal or vascular surgery, where complications are more likely to occur. [11] Studies of neuropsychological complications (e.g. delirium) and studies of transplantation procedures were excluded.

Conference proceedings, non-empirical data and articles that were published before the year 2000 or with the majority of their participants recruited before the year 2000 were excluded. This current approach in the selection of literature was expected to reduce bias resulting from studies of out-dated surgical practices.

Study selection

A total of 50% of the abstracts were reviewed independently by two researchers (AP and RD) and disagreements were resolved by consensus. The remaining half of the retrieved abstracts were reviewed by the primary researcher (AP) based on the consensus that was achieved for the first half. After excluding ineligible articles at abstract and title level, the remaining articles were assessed in full text. The eligibility criteria were applied again on each article. Reasons for exclusion were coded. Articles for which there was uncertainty were discussed between the primary researcher (AP), a researcher with background in psychology (RD) and a researcher with background in surgery (AA). Any disagreements were resolved by consensus.

Data extraction and quality assessment

The primary researcher (AP) and a researcher with a background in surgery (AA) independently extracted data from 20 articles, which they reviewed for any disagreements. Disagreements were resolved by consensus or referral to a third senior researcher (OF). Data were extracted from the remaining articles by the primary researcher and were later checked by the second reviewer (AA). A total of 10 authors were contacted by email to provide information that was not included in the manuscripts. Three articles were excluded from the analysis because their authors did not respond to our requests for further information. Information was extracted from each article on study aims, participants' characteristics, study design, surgical procedures, surgical complications (i.e. types, definitions and method of recording, where available), psychosocial outcomes (i.e. scales, and time-points of measurement), and the association of psychosocial outcomes with surgical complications. The latter included any reported findings on the association of surgical complications with the psychosocial outcomes, including both overall scale and sub-scale scores where available.

The quality of the included studies was assessed with the Newcastle Ottawa scales (NOS). [12] The scales were modified in order to reflect the research questions of the review and to also incorporate the assessment of cross-sectional studies.

Data synthesis

The included studies were first synthesised narratively (i.e. using words and text). In order to quantify the degree of the impact of surgical complications on psychosocial outcomes quantitative procedures were also used. A meta-analysis was conducted on each extracted psychosocial outcome using Review Manager (version 5.2).[13] I^2 was used to calculate the heterogeneity present in the meta-analyses. Heterogeneity was considered low when it was below 25% and high above 50%. [14] A random effects approach was chosen, as a degree of heterogeneity between studies should always be assumed in social sciences. [15] Where multiple assessments were conducted in one single study, only the one furthest from the participants' surgery was included in the meta-analysis.

Results

18,585 articles were retrieved in total across the three databases. After removing duplicate references, a total of 13,605 papers were reviewed at abstract and title level. 994 articles remained to be assessed in full text. A total of 51 articles (50 studies) were eligible for inclusion in the final stage of the review (see Figure 1).

-Figure 1 -

Study characteristics

Details of the included studies are presented in Tables 1-3. A total of 28 studies were conducted in Europe, 14 in the US, three in Australia, two in Turkey, one in Egypt, one in Japan, and one in Taiwan. There were 29 studies in gastro-intestinal, [16-44] 17 in cardio-thoracic, [45-62] and four in vascular surgery. [63-66] The majority of the included studies (40 studies) assessed major procedures. The most common indications for surgery were heart conditions, followed by different types of cancer. Twenty-three studies examined the association between surgical complications and patients' wellbeing as a primary research aim. [17, 19, 28, 30-38, 43, 47, 48, 50-53, 55, 62, 64, 66] The remaining examined this relationship as part of an exploration of the association of different clinical factors with patients' postoperative wellbeing. The majority of the studies were cohort studies. There were four case-control and 20 cross-sectional studies. The majority of the studies were prospective, including baseline measures of psychosocial outcomes.

Quality of life was the main reported psychosocial outcome. Three studies measured anxiety,[30, 40, 62] four studies measured depression,[31, 41, 49, 62] and one study measured mood states.[41] No other psychosocial outcomes were measured. The SF-36 (and its associated versions, i.e. SF-12, SF-20) was the most commonly used scale for the measurement of quality of life.[18, 25-31, 36-38, 42, 43, 45, 46, 48, 51-55, 57-59, 61, 63]

The vast majority of the studies used a-priori definitions of complications. For example, Bloemen et al. recorded only severe complications based on a grading system of surgical complications. [19] Dasgupta et al., also recorded major complications which were defined as "those associated with systemic illness requiring transfer to a higher level of care or requiring relaparotomy, or complications needing interventional radiology". [23] Others used pre-defined categories of complications such as infections, respiratory complications, chronic postoperative pain or perioperative myocardial infarctions. A total of 14 studies did not define or describe the complications that were recorded. The majority of the studies recorded a range of post-operative

complications. 18 studies focused on a single category of complications (e.g. anastomotic leaks, peri-operative myocardial infarctions, wound complications, atrial fibrillation). Complications were mostly recorded through medical records review, clinical examinations and review of administrative databases.

Study quality varied. The scores of the included studies ranged from 2 to 8, with a mean score of 5.9. Points were deducted for the following reasons: lack of information on how complications were defined or on the methods for their recording,[16-18, 21-23, 25, 29, 35, 37, 40-42, 46, 51, 55-57, 61, 63] lack of information on response rates,[16, 21, 22, 25-27, 29, 37, 40, 50, 52, 54, 55, 57, 60, 61] baseline psychosocial outcomes were either not measured or controlled for, [17, 19, 20, 25, 27, 30-36, 38-40, 43-45, 47, 49, 53, 63] and demographic or clinical factors were not controlled for. [20, 25, 27, 31, 32, 34, 40, 43, 45, 51, 56, 61, 63] 7 studies scored exceptionally low (i.e. below 4).

-Tables 1,2,3-

The impact of surgical complications on patients' wellbeing

The majority of studies (n=32) found that patients who suffered surgical complications had significantly worse post-operative psychosocial outcomes than patients with uncomplicated recovery.[16-20, 22, 24, 25, 28, 30, 31, 33, 35-37, 39, 41-48, 50-52, 54, 57, 60, 62, 65] This was the case not only after major surgical procedures but also after relatively minor operations such as hernia repairs. [30, 18, 28, 31, 43] The vast majority (n=25, 78%,) were of high quality (i.e. quality assessment score greater than 6 out of 8). For instance, more than half of the studies with significant findings had measured and controlled for patients' baseline psychosocial outcomes (n=18) [16, 18, 22, 24, 28, 37, 41, 42, 46, 48, 50-52, 54, 57, 60, 62, 65] and used multivariate analyses (n=21), [16, 18, 19, 22, 24, 25, 28, 35, 37, 39, 41, 42, 44, 46, 47, 50, 52, 54, 60, 62, 65] suggesting that complications remained a significant independent predictor of patients' postoperative wellbeing even after controlling for a range of clinical and demographic factors. Psychosocial outcomes that were significantly negatively affected by surgical complications included physical, emotional, and social aspects of patients' quality of life as well as anxiety and depression levels (see Table 4).

Complications that were found to be significantly associated with worse psychosocial outcomes included both major events such as perioperative myocardial infarctions after CABG, [50] severe incontinence after internal sphincterectomy [31] or graft-related events after vascular surgery, [65] and minor complications such as wound infections after hepatic resection, [20] or new cardiac arrhythmias after CABG. [54] The complications that were significantly associated with patients' post-operative psychosocial outcomes are presented in Tables 1-3.

Six studies reported a confounding association between surgical complications and patients' wellbeing (i.e. complications were significantly associated with worse psychosocial outcomes only under certain conditions) [21, 32, 40] or complications were significantly associated with psychosocial outcomes at univariate but not at multivariate analysis. [49, 59, 64] A total of 12 studies did not find a significant association of surgical complications with postoperative psychosocial outcomes. [23, 26, 27, 29, 34, 38, 53, 55, 56, 61, 63, 66] The majority of them (n=7) scored below 6 on quality assessment. For example, four studies had very small samples. [26, 27, 34, 38]

-Table 4 -

Meta-analyses

A series of supplementary meta-analyses were attempted on each extracted psychosocial outcome (i.e. quality of life, anxiety, depression). For a meta-analysis on quality of life, a synthesis of data from widely disparate assessment tools with very different composite scores (e.g. social, emotional, and physical) was not considered valid. For that reason only studies that used the SF-scales [67] were considered as they were the most commonly used quality of life measures. Only three studies had sufficient data on the SF physical and mental quality of life component scores. [28, 31, 45] The pooled mean differences (MD) between the two groups were statistically significant (p<0.001), indicating lower levels of physical (MD=-3.28, CI=-4.71, -1.86) and mental (MD=-3.82, CI=-4.97, -2.67) quality of life in patients who suffered complications compared to patients without complications. Two studies provided sufficient data for a meta-analysis on anxiety. [30, 62] The pooled standardised mean

difference was not significant (p>0.05). A meta-analysis on depression was not possible as there was only one study with available data. [30]

For a more detailed report of the meta-analyses see supplementary materials 2-4.

The duration of the impact of surgical complications on patients' wellbeing

Eighteen studies which reported significant associations of complications with post-operative psychosocial outcomes found a significant relationship of the presence of post-operative complications with worse psychosocial outcomes at 12 months post-surgery or later. [16, 19-22, 25, 28, 30-33, 36, 37, 47, 48, 50, 51, 65] Twenty studies reported a significant association of complications with worse psychosocial outcomes at less than 12 months post-surgery. [17, 18, 24, 35, 39-46, 49, 52, 54, 57, 59, 60, 62, 64]

Discussion

This is, to our knowledge, the first systematic review of the literature investigating the impact of surgical complications on patients' psychosocial wellbeing. In line with our hypothesis, two thirds of the included studies found a significant negative association between the occurrence of surgical complications and patients' postoperative wellbeing. The vast majority of those studies were of high quality. For instance, more than half of the studies with significant findings found that complications were an independent predictor of post-operative psychosocial outcomes after controlling for pre-existing differences on psychosocial outcomes, clinical and demographic variables.

Significant associations were reported in individual studies between surgical complications and lower scores on physical, emotional and social dimensions of the various quality of life measures. A meta-analysis of three studies with sufficient QOL data collected with the SF-scales suggests significant adverse effects of complications both on the physical and the mental health components.

These findings are in agreement with earlier preliminary findings on the psychological burden that surgical adverse events often impose on patients. [3, 4] Surgical complications were also significantly associated with higher post-operative anxiety and depression in individual studies, even though a population effect could not be shown due to the very small number of studies that measured the impact of surgical complications on anxiety and depression. Despite the fact that quality of life is a useful screening outcome offering a general picture of a person's physical health and psychological state, [68] future studies on the psychosocial impact of surgical complications should also consider outcomes such as anxiety and depression as they offer a more accurate picture of a person's psychological wellbeing. Other relevant psychological outcomes such as post-traumatic stress, which was not measured in any of the included studies, would also be of relevance for future research in this area. It is also worth noting that strong conclusions cannot not been drawn on the basis of the meta-analyses results due to the small number of studies included in them.

Complications that were found to significantly contribute to patients' low post-operative wellbeing ranged from severe adverse events such as anastomotic leaks after gastro-intestinal surgery or perioperative myocardial infarctions after cardiac surgery to relatively minor complications such as wound infections or atrial fibrillation. It appears therefore that other than severe post-operative events, minor complications could also cause psychological distress during patients' recovery. For instance, wound complications could affect patients' satisfaction with their body image which could further compromise their quality of life and psychological wellbeing. [69] This finding potentially implies that the severity of complications as judged by healthcare professionals does not always correspond with patients' experience of complications. Moreover, complications were negatively associated with post-operative psychosocial outcomes not only after major surgical procedures but also after relatively minor operations, [30, 18, 28, 31, 43] which suggests a potential independence of the magnitude of initial surgery with the effect of complications on patients' wellbeing. Further research on how complications affect patients' wellbeing after different types of surgery could help clarify this finding.

A number of studies also found a significant negative contribution of surgical complications to psychosocial outcomes more than one year post-operatively, suggesting that patients may suffer psychologically due to the experience of surgical complications for an extensive period of time after surgery. The above findings hold important implications for patients' recovery as there is growing evidence on the role of psychological stress in compromising the function of the immune system and slowing down wound healing. [7-9] Surgical complications are likely to further prolong patients' recovery in almost a reciprocal cycle of distress and decreased immune function. The exact relationships between surgical complications, psychological distress and speed of recovery warrant further investigation.

It is noteworthy that a smaller number of studies did not find a significant association between complications and patients' postoperative psychosocial outcomes or found significant univariate associations which were not replicated in multivariate analyses. Even in studies showing a significant impact there will be many patients who largely maintain their psychological health and quality of life in the aftermath of complications. Other than clinical factors, patients' ways of coping with stress, their appraisals of surgery and their health, as well as their perceptions of support from their loved ones and healthcare professionals could explain the conditions under which complications affect patients' wellbeing, as suggested by wider literature on patients' adjustment after surgical treatment. [70- 72] The role of psychological factors as potential moderators of the psychological impact of surgical complications needs to be further explored.

Overall the quality of the included studies was good as indicated by their relatively high quality assessment scores and the small number of studies that scored exceptionally low. A substantial number of studies with significant findings controlled not only for patients' pre-operative psychosocial outcomes but also for a variety of clinical and demographic factors confirming that surgical complications were an independent predictor of postoperative psychosocial outcomes above and beyond any pre-existing differences. The fact that the included studies used validated

self-report measures for the measurement of psychosocial outcomes and the use of a very comprehensive search strategy also increase the validity of the findings.

Limitations

A few caveats should be borne in mind when interpreting the above findings. Firstly, one third of the studies did not define complications or did not describe the methods they used to record complications. Moreover, almost one third of the studies did not provide information on response rates, which does not allow inferences about the representativeness of their samples.

Regarding the methodology of the systematic review, studies that were published before the year 2000 or with the majority of patients recruited before the year 2000 were excluded, albeit limiting this review to literature that was published in the last decade is expected to be more reflective of current surgical practice. It should also be noted that studies that were published past the final run of the search strategy (i.e. May 2012) have not been considered. Caution should also be taken when interpreting these findings to other specialties as the clinical setting in which complications occur may affect their impact on patients' wellbeing. Another limitation was the very small number of studies with sufficient data for quantitative synthesis and the difficulty of synthesising data from different quality of life measures, which resulted in restricting the meta-analyses on data collected only with the SF scales. The small number of studies with available data did not permit certain types of sensitivity analyses such as by surgical specialty, type of surgery (i.e. minor versus major surgery) or underlying disease (e.g. cancer versus other conditions), which could be significant determinants of the impact of complications on patients' wellbeing. Lastly, there is always the potential for publication bias where studies with significant results and big effect sizes are more easily published.[73-75] It is worth adding that none of the included studies were randomised controlled trials due to the non-appropriateness of this design for the research questions that this review aims to answer.

Implications of findings

The results highlight the importance of considering patients' psychological needs in the aftermath of surgical complications. Surgical and nursing staff need to be aware of the challenges of surgical complications for patients' wellbeing and ensure that their psychological needs are not neglected. Screening patients who suffer post-operative complications for symptoms of psychological distress could help identify those patients who need psychological support. Facilitating patients' access to psychological support during and after their hospital stay could also be of great value for patients' post-operative wellbeing. For example, early referral to psychological services could prevent long-term psychological distress and may also mitigate the negative effects of stress on patients' recovery. Primary care practitioners and carers need to be aware of the psychological burden that surgical complications impose on patients in order to recognise their distress in time and to provide the support that patients need.

Conclusions

This is the first systematic review of the literature on the impact of surgical complications on patients' psychosocial wellbeing. The findings of this review suggest that surgical complications are potentially a significant independent predictor of patients' impaired post-operative psychosocial wellbeing often for a very long time post-surgery. It also appears that other than major complications relatively minor adverse events may also compromise patients' psychosocial wellbeing, which implies that the clinical severity of complications may not always indicate how seriously patients will be affected by them. Patients who experience surgical complications report worse levels of different aspects of quality of life than patients with uncomplicated recovery, often more than a year after their operation. The ways in which complications are managed (e.g.

reoperation versus conservative management), the type of surgery (e.g. minor versus major), the underlying disease (e.g. cancer versus other conditions), psychological factors (e.g. patients' perceptions of support, illness perceptions, coping strategies) or cultural influences may be key moderators of the impact of surgical complications on patients' psychosocial wellbeing. Future research is needed on the contribution of the above factors on the impact of surgical complications on psychological outcomes such as anxiety, depression and post-traumatic stress, as well as on how to support patients who experience a complicated post-operative recovery.

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Data sharing: No additional unpublished data

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Table 1: Key characteristics of gastro-intestinal surgery studies (n=29)

First author's name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of surgical complications with patients' wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Anthony	2003	US	Secondary	Nt1=71/? Nt2=63 Nc=16	Colorectal cancer, male patients who underwent open surgical therapy	Observational, cohort, prospective	Open surgical therapy for colorectal cancer	*Morbidity* was defined as any event that resulted in the need for additional therapy or readmission to the hospital within 30 days of initial discharge/Method not specified	Quality of life (QOL)/at time of diagnosis and 12 months after surgery/FACT-C[1]	YES*	Any complications/12 months post- surgery	**6**
Avery	2006	UK	Primary	N=139/162 Nc=37	Patients with esophageal or gastric cancer who underwent upper gastro-intestinal surgical treatment	Observational, cross-sectional	Upper gastro-intestinal surgical treatment for esophageal or gastric cancer	A major complication was defined as reoperation, readmission to the high-dependency or intensive care unit, readmission to the hospital within 30 days of operation, or death within 30 days of operation or later if the patient did not leave the hospital/Method not specified	QOL/39.6days after treatment (range,6–105)/EORTC QLQ-C30[2]	YES	Any complications/39.6 days after treatment (range: 6–105)	**5**
Bitzer	2008	Germany	Secondary	Nt1=151/205 Nt2=130 (86.1%) Nc(complaints)=49 Nc(wound infection)=5 Nc(seroma)=13 Nc(pneumonia)=1 Nc(other)=28	Patients undergoing cholecystectomy	Observational, cohort, prospective	Cholecystectomy	Retrospective list: Any complaint, Wound infection, Seroma, Pneumonia, other complaints/Patient reports	QOL/14 days pre-op, 14 days post-op, and 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**7**
Bloemen	2009	Netherlands	Primary	N=121/170 Nc=33	Rectal cancer patients	Observational, cross-sectional	Surgical treatment for adenocarcinoma of the rectum	Only severe complications were considered: Grade III or IV complications (according to Dindo's model) were defined as severe, whereas absence of complications or Grade I and II complications were defined as absent or mild complications/patient records	QOL/36 (16–51) months post-op /EORTC QLQ-C30 & CR38[3]	YES	Severe post-operative complications/Median of 36 (range, 16–51) months post-surgery	**6**
Bruns	2010	Germany	Secondary	N=96/188 Nc(any morbidity)=30 Nc(wound infections)=10	Patients who underwent curative hepatic resection for malignant or non malignant diseases, disease free at time of assessment	Observational, cross-sectional	Hepatectomy	Surgical (e.g. bile leak or biloma, pneumothorax, wound infection, liver abscess, bleeding, and surgical dehiscence) and medical (e.g. pleural effusion, renal failure, hepatic failure, pneumonia, cardiac insufficiency, and cholangitis)/patient records	QOL/ 3-36 months post-op /SF-12	YES	Wound infections/3-36 months post-surgery	**5**

[1] Functional assessment of cancer therapy questionnaire with the colorectal module
[2] European Organisation for Research and Treatment of Cancer core
[3] European Organisation for Research and Treatment of colorectal cancer

Champault	2006	France	Secondary	Nt1=152/? Nt(4)=139 Nc=(unclear)	Consecutive patients operated on for morbid obesity.	Observational, cohort, prospective	Laparoscopic placement of a gastric band	Retrospective list: pulmonary atelectasis or pneumonia, prolonged ileus, minor wounds problems and urinary retention. Slippage with a peak incidence during the second postoperative year. Band erosion with penetration into the stomach. Access port problems (infection, hematoma, leak, disconnection), bands explanted, associated with erosion, obstruction, immediate intolerance, and recurrent tubing break/Method not specified	QOL/pre-op, 1, 3 months & 2 years post-op/GIQLI[4]	CONFOUNDING*	Band removal for complications such as erosion, slippage, intolerance/2 year post-surgery	**6**
Chang	2010	Taiwan	Secondary	N=102/218 Nc(anastomotic stricture)=12 Nc(gastrojejunal anastomotic ulcer) =9 Nc(upper gastro-intestinal bleeding) =1 N(GORD)=2	Patients undergoing bariatric surgery.	Observational, case-control, longitudinal	Roux-en-Y bypass	Operation related complications, including gastrojejunal anastomotic stricture, gastrojejunal anastomotic ulcer, upper gastro-intestinal bleeding and GORD/Method not specified	QOL/pre-op, 1, 3, 6 and 12 months post-op/WHOQOL-BREF[5]	YES*	Any complications/1, 3, 6, 12 months post-surgery	**5**
Dasgupta	2008	UK	Secondary	Nt1=102/122 Nt2=87 Nt3=80 Nt4=33 Nc=44	Consecutive, patients undergoing liver surgery for liver cancer	Observational, prospective, cohort	Liver resection for hepatic malignancies	Major complications were defined as those associated with systemic illness requiring transfer to a higher level of care (high-dependency or intensive care unit) or requiring relaparotomy, or complications needing interventional radiology/Method not specified	QOL/pre-op, 6, 12, 36-48 months post-op/EORTC QLQ-C30	NO*	N/A	**6**
Delaney	2003	US	Secondary	Nt1=109/109 Nt2=82/109 Nc(any)=19 Nc(major)=9	Patients with Crohn's Disease	Observational, cohort, prospective	Surgery for CD (abdominal perineal, loop or end stoma)	Retrospectively listed complications: anastomotic leak, intraabdominal abscess, bleeding, venous thrombosis, renal failure, and pneumonia, dehydration, intraabdominal abscess, small bowel obstruction and wound infection/Database review	QOL/pre-op & 30 days post-op/CGQL[6]	YES*	Any complications/30 days post-op	**7**
Douma	2011	Netherlands	Secondary	N=296/? Nc=?	296 patients with FAP who had been surgically treated	Observational, cross-sectional	Surgery for familial adenomatous polyposis (FAP)	Surgery-related complications/Self-reports + medical records	QOL/0 to >10 years post-op/SF-36, EORTC-QLQ-C38,Social Functioning subscale of the Dutch version of IBDQ[7]	YES	Any complications/0 to >10 years post-surgery	**2**
Dubernard	2006	France	Secondary	Nt1=58/? Nt2=58 Nc=9	Women with colorectal endometriosis who underwent a segmental colorectal resection	Observational, cohort, prospective	Laparoscopic segmentalcolorectal resection for endometriosis	Retrospectively listed complications: rectovaginal fistulae, vessel injury of the protective colostomy treated by laparoscopic coagulation, uroperitoneum requiring a ureteral stent for 6 weeks and an abscess behind colorectal anastomosis requiring a laparoscopic drainage/Patient observations	QOL/pre & post-op/SF-36	NO*	N/A	**6**
El-Awady	2009	Egypt	Secondary	N=40/? Nc=14	Patients with inguinal hernia	Observational, prospective, cohort	Anterior open Lichtenstein tension free hernioplasty	Postoperative complications: seroma, haematoma, 2ry infection, neuralgia and anaesthesia/patient observations	QOL/pre-op, 3, 6 &12 months post-op/SF-36	NO	N/A	**4**

[4] Gastrointestinal Quality of Life index
[5] World Health Organization Quality of Life – Brief
[6] Cleveland Global Quality of Life
[7] Inflammatory Bowel Disease Questionnaire

Hawn	2006	US	Primary	Nt1=1983/3518 Nt2=1526 (77%) Nt3=1603 (81%) Nc(neuralgia t1)=94 Nc(hematoma t1)=51 Nc(orchitis t1)=13 Nc(recurrence t1)=76 Nc(other t1)=124 Nc(neuralgia t2)=105 Nc(hematoma t2)=55 Nc(orchitis t2)=18 Nc(other t2)=150	Men who received a hernia repair.	Observational, cohort, prospective	Inguinal herniorrhaphy	Complications were summarized by 4 categories: (1) hematoma/seroma, (2) orchitis, (3) neuralgia of the leg or groin, and (4) other. Complications classified as "other" included: (1) early postoperative complications (urinary tract infection, urinary retention, and hematuria); (2) life-threatening complications (respiratory insufficiency, myocardial ischemia, cardiac arrhythmia, intraoperative hypotension, and stroke); and (3) long-term complications (4 weeks or more postoperative)/Patient reports for neuralgia & orchitis + Expert consensus for life-threatening complications	QOL/pre-op, 1 &2 years post-op/SF-36	YES*	Neuralgia, orchitis/2 years post-surgery	**8**
Ince	2011	US	Secondary	Nt1=?/568 Nt2=166 Nc=?	Patients who underwent colorectal resection for benign and malignant diseases.	Observational, cohort, retrospective	Laparoscopic colorectal resection	No reference	QOL/pre-op, 4weeks post-op/SF-36	NO*	N/A	**3**
Kalliomaki	2009	Sweden	Primary	N(total)=184/423 N1=92 (cases) N2=92 (controls)	Patients who had been operated on for groin hernia. Controls matched for age, gender and method of surgical repair were allotted from the group of persons without persisting pain (Grade 1 in IPQ)	Observational, case-control, cross-sectional	Hernia repair	Persistent postoperative pain (patients with pain of Grade 3, i.e. pain that could not be ignored but did not interfere with everyday activities, or higher on IPQ)/Patient reports (Inguinal Pain Questionnaire) & clinical examination	QOL, anxiety, depression/(on average 4.9 years post-op, range > 7 years)/SF-36, HADS[8]	YES	Persistent post-op/Mean of 4.9 years post-surgery	5
Kement	2011	Turkey	Primary	N=253/351 N(incontinence)=28 N(severe incont)=9 N(mild incont)=19	Consecutive patients with chronic anal fissure who underwent open LIS.	Observational, cross-sectional	Open lateral internal sphincterotomy	Anal incontinence/Patient reports: Wexner Incontinence Score system (WIS) + Clinical examination	QOL/23.3 +/- 7.1 months post-op/SF-36	YES	Severe incontinence/23.3 (SD ± 7.1) months post-surgery	**5**
Lim	2006	UK	Primary	N=92/112 Nc(leaks)=23 Nc(clinical leaks)=13 Nc(sub-clinical leaks)=10	Consecutive patients under the care of three consultant surgeons who underwent procedures with LRA	Observational, cross-sectional	Low rectal anastomosis (LRA)	Anastomotic leaks (clinical & subclinical)/Patient observations, CT scans, WCE	QOL/10-18 months post-op/EORTC QOL	CONFOUNDING	Anastomotic leaks/10-18 months post-op	**5**

8 Hospital Anxiety and Depression Scale

Liu	2010	US	Primary	N=679/1308 Nc(early comps/anast)=54 Nc(late comps/anast)=126 Nc(early comps/anast/rectal cancer only)=42 Nc(late comps/ostom/rectal cancer only)=105	Long-term Colorectal Cancer patients	Observational, cross-sectional	Colorectal cancer surgery	-Digestive, skin, genitourinary, surgical, medical, immediate indirect complications -Early complications: those that were first recorded within 30 days of the surgery. Late complications: occurring 31 days after surgery/Patient computerised data	QOL/ 5-15 years post-op/mCOH-QOL-Ostomy[9]	YES	Enterocutaneous fistula for all patients & any late complications for ostomy patients>5 years post-surgery	6
Mentes	2006	Turkey	Primary	Nt1=253/302 Nt2=244 Nc(anal fistula/abscess)=3 Nc(FISI>0)=7 Nc(FISI, 0->4, 21, 7)=3	Patients who underwent Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Observational, cohort, prospective	Lateral internal sphincterotomy (LIS) for chronic anal fissure (CAF)	Anal Incontinence/Patient examination+ FISI score	QOL/pre-op (admission) & 12 months post-op/GIQLI & FIQL[10]	UNCLEAR (due to small number of patients with complications)	N/A	6
Pittman	2008	US	Primary	N=239/322 Nc=56	Veterans with an ostomy after major gastro-intestinal surgery requiring an intestinal stoma	Observational, case-control, cross-sectional	Gastro-intestinal surgery requiring an intestinal stoma	Ostomy complications: skin problems, leakage, and difficulty with adjustment (i.e. leakage, peristomal irritant dermitis, pain, bleeding, stomal necrosis, prolapse, stenosis, herniation, retraction, infection, mucotaneous separation, difficulty adjusting)/Patient reports	QOL/6months post-op/mCOH-QOL-Ostomy	YES	Ostomy complications (skin problems, leakage)/ 6 months post-surgery	6
Polese	2012	Italy	Primary	N=147/211 Nc(anastomotic stenoses)=22	Patients who underwent elective left colonic or rectal resection and colorectal anastomosis for neoplastic or inflammatory disease.	Observational, cross-sectional	Left colonic or rectal resection and colorectal anastomosis	Anastomotic stenosis/Clinical examination	QOL/mean 58 (SD ± 31) months post-op/SF-36	YES	Anastomotic stenosis/58 (SD ± 31) months post-surgery	6
Rea	2007	US	Primary	Nt1=505/? Nt2=237 Nt3=106 Nc(t2)=41 Nc(t3)=23	Patients who underwent LRYGB by one surgeon for morbid obesity	Observational, cohort, prospective	LRYGB for morbid obesity without conversion to an open procedure.	Postoperative complications requiring intervention/Method not specified	QOL/baseline, 1 & 2 years post-op/SF-36	YES*	Complications requiring intervention/1 & 2 years post-surgery	6

9 City of Hope Quality of Life for Ostomates questionnaire
10 Fecal Incontinence Quality of Life Instrument

Riss	2011	Austria	Primary	N1=16/36 (cases) N2=16/? (controls)	Cases: patients operated for rectal cancer and developed anastomotic leak. Controls: Patients operated for rectal cancer at the same time period and had an uneventful postoperative course matched by sex, age (±5 years), type of resection, and neoadjuvant therapy.	Observational, case-control, cross-sectional	Rectal resection for malignancies on overall pelvic organ function	Anastomotic leakage: Defined as grade A (no change in patient's management), grade B (requires active therapeutic intervention but is managed without relaparotomy) and grade C (requires relaparotomy)/Review of the institutional colorectal database and individual chart reviews	QOL/106.8 months post-op (32.4–170.4)/SF-12	NO	N/A	**7**
Rutegard	2008	Sweden	Secondary	N=355/ 446 (79·6 %) Nc=56	Patients diagnosed with an oesophageal or cardia cancer who underwent macroscopically and microscopically radical resection	Observational, cross-sectional	Oesophageal resection	Technical surgical complications, including postoperative bleed exceeding 2000 ml or requiring a reoperation, anastomotic insufficiency, necrosis of the substitute, damage to the recurrent nerve, thoracic duct damage or gastric perforation/Prospective scrutiny of medical and histopathological records, operation charts, extensive study protocol with predefined exposure alternatives	QOL/6months post-op/EORT QLQ-C30, & QLQ-OES1812 [11]	YES	Technical complications/6 months post-surgery	**7**
Scarpa	2009	Italy	Secondary	N=47/? Nc=?	Patients admitted for intestinal surgery for Crohn's Disease	Observational, cross-sectional	Bowel resection through midline laparotomy or with laparoscopic assistance, end ileostomy, stricturoplasty	Medical and surgical complications and need of reoperation (2 anastomotic leaks, 3 intestinal obstructions, 2 intestinal bleeding, and a wound infection were recorded and two re-laparotomies)/Method not specified	QOL/3 months post-op/CGQLI	CONFOUNDING	Any complications/3 months post-surgery	**3**
Sharma	2007	UK	Secondary	Nt1=104 /110 Nt2=92 Nc=41	Consecutive patients with newly diagnosed colorectal cancer scheduled for elective open resection in one hospital trust	Observational, cohort, prospective	Elective resection for colorectal cancer	Wound, urinary tract and chest infections, cardiac and respiratory complications, deep venous thrombosis, pulmonary embolism and complications related to anastomotic breakdown/Method not specified	QOL, anxiety, depression, positive vs. negative affectivity, mood states/pre-op (5-12 days pre-op) & 6-8 weeks post-op/FACT-C, EuroQOL (EQ-5D), HADS, PANAS[12], MRS[13]	YES*	Complications within 30 days of operation/6-8 weeks post-surgery	**6**
Siassi	2009	Germany	Secondary	Nt1=93/113 Nt2,t3=79 Nc=26	Patients undergoing colorectal surgery for benign and malignant disease	Observational, prospective, cohort	Resection of the sigmoid colon or rectum	Postoperative complications (anastomotic leak, wound infection, delayed food intake, fever, and bladder dysfunction)/Method not specified	QOL/pre-op, 3 & 12 months post-op/SF-36 & GLQI[14]	YES*	Any complications/3 months post-surgery	**7**

[11] Oesophageal cancer-specific questionnaire
[12] Positive and negative affect schedule
[13] Mood rating scale
[14] Gastrointestinal Quality of Life Index

Targarona	2004	Spain	Primary	N=37/46 Nc(recurrent hernias)=3	Patients diagnosed with paraesophageal or mixed hiatal hernia (types II, III, and IV) with >50% of the stomach in the chest.	Observational, cross-sectional	Laparoscopic repair of paraesophageal hiatal hernia	Hernia recurrence (any migration of the cardia to chest level or evidence of a new paraesophageal sac)/A barium swallow was given to all patients to rule out an anatomic recurrence. An independent radiologist evaluated all the explorations.	QOL/>=6 months post-op (median, 24; range, 6–50)/SF-36, GDSS[15] and GIQLI	YES	Clinically recurrent hernias/>=6 months post-surgery	**5**
Viklund	2005	Sweden	Secondary	N=100/146 Nc=44	Patients newly diagnosed with a histologically verified adenocarcinoma or squamous-cell carcinoma of the esophagus or adenocarcinoma of the gastric cardia that underwent macroscopically and microscopically radical tumor resection.	Observational, cross-sectional	Esophageal resection surgery for cancer	Anastomotic leakage , infections, respiratory insufficiency, cardiac complications, technical complications, anastomotic strictures, and others (intervention needed to treat embolus, deep venous thrombosis, rupture of the wound, intestinal obstruction, stroke, renal failure, or liver failure)/Patient records	QOL/6 months post-discharge/QLQ-C30 & OES-24[16]	YES	Any complications, anastomotic leakage, infection, respiratory insufficiency, cardiac complications, technical complications/6 months post-discharge	**7**

***Study controlled for patients' preoperative wellbeing**

[15] Glasgow Dyspepsia Severity Score
[16] Symptoms specific to oesophageal cancer

Table 2: Key characteristics of cardio-thoracic surgery studies (n=17)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome/time-points/measurement tool	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Deaton	2009	US	Secondary	Nt1= 317/442 Nt2=270 Nc=44% (130)	Patients with documented T2DM undergoing CABG	Observational, cohort, prospective	CABG	Infection of the leg, thorax, sternum, bloodstream or urinary tract; central neurological deficit (stroke or transient ischemia, coma); pneumonia, pulmonary insufficiency with prolonged ventilation or re-intubation, pulmonary embolism; renal failure; arrhythmias requiring treatment; prolonged inotropic support or use of intra-aortic balloon pump; or reoperation for bleeding or tamponade/Patient records	QOL/ 3 months post-op/SF-36	YES	Any complications/3 months post-surgery	**6**
El Baz	2008	Netherlands	Secondary	Nt1=198/256 Nt2=168 Nc=?	Consecutive patients who were scheduled for CABG following a coronary angiography	Observational, cohort, prospective	CABG	Postoperative events such as use of inotropes, atrial arrhythmias, or ventricular arrhythmias, sternal resuturing, re-exploration for bleeding, and time spent on mechanical ventilation/Registry database, medical notes, outpatient notes and intensive therapy unit charts	QOL/pre-op & 6 months post-op/SF-36	YES*	Re-exploration for bleeding and sternal resuturing/6 months post-surgery	**8**
Ferguson	2009	US	Primary	N=124/221 Nc=22	Prospective patients who underwent major lung resection for early stage lung cancer.	Observational, cross-sectional	Major lung resection for early stage lung cancer (lobectomy, bilobectomy, pneumonectomy)	Complications were categorized as pulmonary (pneumonia, prolonged intubation, reintubation, air leak more than 7 days, lobar collapse requiring intervention), cardiovascular (pulmonary embolism, myocardial infarction, new postoperative arrhythmia, need for intravenous inotropic agents), other, and any complication/Administrative database, hospital medical records, office shadow files	QOL/average of 2.6 years post-op (3 months to 6.4 years)/EORTC QLQ-C30, EORTC QLQLC13[17] and DASS-21[18]	YES	Pulmonary complications/2.6 years post-surgery (Range: 3 months-6.4 years)	**6**
Gjeilo	2010	Norway	Primary	Nt1=534/631 Nt2=462 Nt3=465 Nc(t2)=52	Patients undergoing cardiac surgery	Observational, cohort, prospective	Midline sternotomy	Chronic pain (pain arising after surgery and persisting either continuously or intermittently for 3 months or more/BPI (Brief Pain Inventory)	QOL/pre-op, 6 & 12 months post-op/SF-36	YES*	Chronic post-surgical pain/12 months post-surgery	**6**
Hata	2006	Japan	Secondary	N=452/452 Nc=?	Consecutive adult patients who underwent open heart surgery	Observational, cross-sectional	CABG	Postoperative morbidity (minor stroke, infection, pneumonia, haemodialysis, paraplesis)/Patient records	Depression/5-7 days post-op/Interviewed by a psychiatrist and CES-D[19]	CONFOUNDING	Post-operative minor stroke and pneumonia/5-7 days post-surgery	**6**

17 EORTC Lung Cancer Questionnaire
18 Short version of the Depression Anxiety Stress Scales
19 Center for Epidemiological Studies Depression Scale

Jarvinen	2004	Finland	Primary	Nt1=501/1128 Nt2=485 Nc=80	Patients who underwent CABG	Observational, cohort, prospective	CABG [89% via sternotomy incision with cardiopulmonary bypass (CPB; on-pump) and 11% without CPB (off-pump)]	Perioperative myocardial infarctions/Clinical examination + clinical tests (ECGs, echocardiography, laboratory tests)	QOL/pre-op & 12 months post-op/RAND-36	YES*	Perioperative myocardial infarctions /12 months post-surgery	**7**
Jideus	2009	Sweden	Primary	N1=73/84 (cases) N2=42/? (controls)	-Cases: patients who developed sternal wound infection (SWI) after cardiopulmonary bypass. -Controls: patients prior to CABG and evaluated 1 year postoperative and matched for time of the operation, age and sex	Observational, case-control, cross-sectional	Cardiopulmonary bypass	Serious wound infections (SWIs: deep infection involving retrosternal tissue and/or the sternal bone)/Clinical examination	QOL/20 months post-op (range 7-40)/SF-36	YES*	Serious wound infections /20 (Range: 7-40) months post-surgery	**4**
Kinney	2012	US	Primary	N=99 Nt1=120/? Nt2=99 Nc=75	Patients aged 45 to 75 years undergoing elective thoracotomy	Observational, cohort, prospective	Serratus-sparing posterolateral thoracotomy or limited thoracotomy	Chronic post-thoracotomy pain/Leeds Assessment of Neuropathic Symptoms and Signs + self-reports	QOL/pre-op, 3 moths post-op/SF-36	YES*	Chronic post-thoracotomy pain/ 3 months post-surgery	**7**
Landoni	2006	Italy	Primary	N1=22/42 (cases) N2=40/42 (controls)	-Cases: patients who underwent cardiac surgery and developed ARF requiring RRT and left the hospital alive. -Controls: matched controls who did not develop ARF and did not receive RRT.	Observational, case-control, cross-sectional	Cardiac surgery (procedures not specified)	ARF (acute renal failure) requiring RRT (renal replacement therapy)/Administrative database, registry	QOL/23-42 months post-op/SF-36	NO	N/A	**`6**
Le Grande	2006	Australia	Secondary	Nt1=182/444 Nt2=128 Nt3=114 Nc=?	Adults on the waiting list for CABG	Observational, cohort, prospective	CABG	Post-surgical complications such as cardiac arrhythmias, stroke and infections/Medical records	QOL/pre-op, 2 & 6 months post-op/SF-36	YES*	New cardiac arrhythmia post-surgery, atrial fibrillation/ 6 months post-surgery	**7**
Martin	2008	US	Primary	Nt1=836/2,007 Nt2=2.007 Nc=189	Patients undergoing elective open heart surgery	Observational, cohort, prospective	Open heart surgery (133 valve procedure; 620 CABG; 67 CABG plus valve procedure; 15 CABG plus other cardiac procedure; and 1 closure of an atrial septal defect)	Perioperative myocardial infarction, mediastinitis, superficial wound infection, septicemia, permanent stroke, transient ischemic attack, continuous coma, prolonged intubation, ventilator-associated pneumonia, cardiac tamponade, atrial fibrillation, reoperation for bleeding, renal failure, renal failure which required dialysis, and length of stay/Method not specified	QOL/pre-op, 1 year post-op/SF-20	NO*	N/A	**6**
Merkouris	2009	Greece	Secondary	Nt1=63/63 Nt2=59 Nt3=56 Nc=42	All patients over 65 presenting a 1, 2 or 3 vessel disease treated with CABG without concurrent procedures (e.g. valve replacement)	Observational, cohort, prospective	CABG	Retrospective list of complications: Atrial fibrillation, re-exploration for bleeding, low cardiac output syndrome, acute respiratory failure, sternal wound infection, neurological dysfunction, mild problems related to leg incision healing or swelling, chest incision discomfort and medications/Method not specified	QOL/pre-op, 4 & 12 months post-op/MacNew Heart Disease HRQOL questionnaire	NO*	N/A	**5**

Moller	2012	Sweden	Secondary	Nt1=249/? Nt2=213 Nc=?	Prospective patients scheduled for lung surgery for lung cancer	Observational, cohort, prospective	Lung surgery	Complication was defined as any of the following postoperative complications: new onset atrial fibrillation, prolonged air leak (chest tubes in place for more than 5 days), pneumonia, re-intubation, reoperation, or hospital stay of 8 days or more/Method not specified	QOL/pre-op, 6 months post-op/SF-36	YES*	Any complications/6 months post-surgery	**6**
Myles	2001 & 2006	Australia	Secondary	Nt1=120/125 Nt2=120 (days 1,2,3) Nt3=108 Nt4=94 Nc=69	Adult cardiac surgical patients	Observational, cohort, prospective	Cardiac surgery (specific procedures not specified)	1. Respiratory: postoperative mechanical ventilation for more than 24 h or pneumonia, defined as pulmonary infiltrate with positive microbial cultures; 2. Cardiac: arrhythmia requiring treatment with antiarrhythmic medication or electrical cardioversion reversion; radiologic evidence of pulmonary edema; or myocardial infarction, defined by new Q waves on electrocardiogram or creatine kinase-MB isoenzyme concentration greater than twice normal; 3. Renal: acute renal failure, defined by serum creatinine concentration greater than 200 M; 4. Neurologic: stroke, defined as a new central neurologic deficit; 5. Sepsis: wound infection requiring excision of tissue or antibiotic therapy, or positive microbial culture (other than pneumonia) -Clinical and laboratory tests (microbial cultures, radiologic data, electrocardiograms etc.)	QOL/pre-op, 1 & 3 months, 3 years post-op/SF-36	CONFOUNDING*	Any complications/3 months post-surgery	**8**
Peric	2008	Serbia & Montenegro	Secondary	Nt1=208/? Nt2=192 Nc=60	Consecutive patients who underwent elective CABG	Observational, cohort, prospective	CABG	Retrospective list of complications: low cardiac output (cardiac index lower than 2 L/min/m2), mechanical ventilation longer than 24 hours, reoperation for bleeding, sternal wound infection, perioperative myocardial infarction, pericardial effusion, arrhythmic complications (atrial fibrillation, ventricular tachycardia, ventricular fibrillation), abdominal complications, and other/Observations, ECGs, echocardiography, laboratory tests	QOL/pre-op, 6 months post-op/Nottingham Health Profile Questionnaire (NHP)	YES*	Any complications/6 months post-surgery	**7**
Rodriguez	2008	US	Secondary	Nt1=397/? Nt2=? Nt3=? Nt4=? Nc=23	Patients diagnosed with upper extremity HH treated with TS.	Observational, cohort, prospective	Thoracoscopic sympathectomy for palmar and axillary hyperhidrosis	-Compensatory sweating (CS): Excessive sweating considered abnormal in other parts of the body after TS. -Gustatory sweating: Facial sweating after eating foods -Excessive dryness: Dryness affecting the hands and requiring hydration -Method not specified	QOL/pre-op, discharge, 6 & 12 months post-op/SF-36	NO*	N/A	**3**
Tully	2011	Australia	Primary	Nt1=226/238 Nt2=222 Nc=56	Patients undergoing first-time CABG surgery	Observational, cohort, prospective	CABG	New-onset atrial fibrillation (AF) between the patient's day of admission to the intensive care unit and the median day of discharge (day 5) after CABG during the index hospitalization/ECGs, transthoracic echocardiographs reviewed by technicians and reviewers blinded to patients' psychological distress scores	Anxiety, Depression, Stress/pre-op (mean=2 days, SD=2 days) & post-op (mean=6 days, SD=2 days)/ DASS[20]	YES*	Atrial fibrillation/6 days (SD=2 days) post-surgery	**7**

***Study controlled for patients' preoperative wellbeing**

[20] Depression Anxiety Stress Scales

Table 3: Key characteristics of studies in vascular surgery (n=4)

First author name	Year	Country	Primary or Secondary aim	**Sample** (N=number of patients in analysis/eligible patients, Nt(i)=sample size per time-point, Nc=patients with complications, N1=Cases vs. N2=controls)	Patient inclusion criteria	Study Design	Type of surgery	Surgical complications/method of recording	Psychosocial outcome & timepoints	Significant association of complications with wellbeing (Yes/No/Confounding)	Types of complications and time-points of significant effects	Quality assessment score (out of 8)
Lohse	2009	Germany	Secondary	N=110/124 Nc=?	Consecutive patients who received a replacement of the dilated ascending aorta.	Observational, cross-sectional	Ascending aorta replacement	Retrospective list: Postoperative bleeding, Myocardial infarction, Stroke, Pneumonia, Respiratory insufficiency, Acute renal dysfunction, Sepsis, Lung fistula/Method not specified	QOL/36.4 ± 15.5 months post-op (11–58 months)/SF-36	NO	N/A	**4**
Nguyen[a]	2007	US & Canada	Primary	Nt1=1296/1404 Nt2=862 Nt3=732 Nc=543	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Lower extremity vein bypass for limb salvage in critical limb ischemia (CLI) patients	Wound complications (WC): patients having infection, necrosis, hematoma-haemorrhage, or seroma-lymphocele at the surgical incision or harvest site within 30 days of the bypass surgery/Adverse events clinical trial documentation with reference to source documentation (hospital notes etc.)	QOL/baseline, 3 & 12 months post-op/VascuQol[21]	CONFOUNDING*	Wound complications/3 months post-surgery	**8**
Nguyen[b]	2006	US & Canada	Secondary	N1=1296/1404 (92.3%) N2=862 (61.4%) N3=732 (52.1%) Nc=?	Patients who underwent IB for Critical Limb Ischaemia (CLI) in community and university hospitals across the US and Canada	Observational, cohort, prospective	Infrainguinal vein grafting for limb salvage in critical limb ischemia (CLI) patients	Graft-related events (GREs): development of a >70% graft stenosis or having undergone a percutaneous or surgical revision or a major amputation/Clinical tests (angiography, ultrasonography etc.), source documentation (hospital notes, discharge notes, operative and procedural notes etc.)	QOL/pre-op, 3 & 12 months post-op/VascuQol	YES*	Graft-related events/12 months post-surgery	**8**
Subramonia	2005	UK	Primary	Nt1=70/70 Nt2=59 Nt3=62 Nc(sensory abnormalities)=25 Nc(bruising at t1)=58 Nc(bruising at t2)=16	Patients with varicose veins, either symptomatic or with skin changes, resulting from incompetence of the LSV as confirmed by handheld Doppler examination or duplex ultrasonography or both and requiring surgical intervention (both day cases and inpatients).	Observational, cohort, prospective	Conventional LSV stripping	-Bruising/Tracing method -Sensory abnormalities, both subjective (paresthesia and dysesthesia) and objective/Patient reports, sensory testing	QOL/pre-op, discharge & 6 weeks post-op/Aberdeen Varicose Vein Questionnaire 2	NO*	N/A	**7**

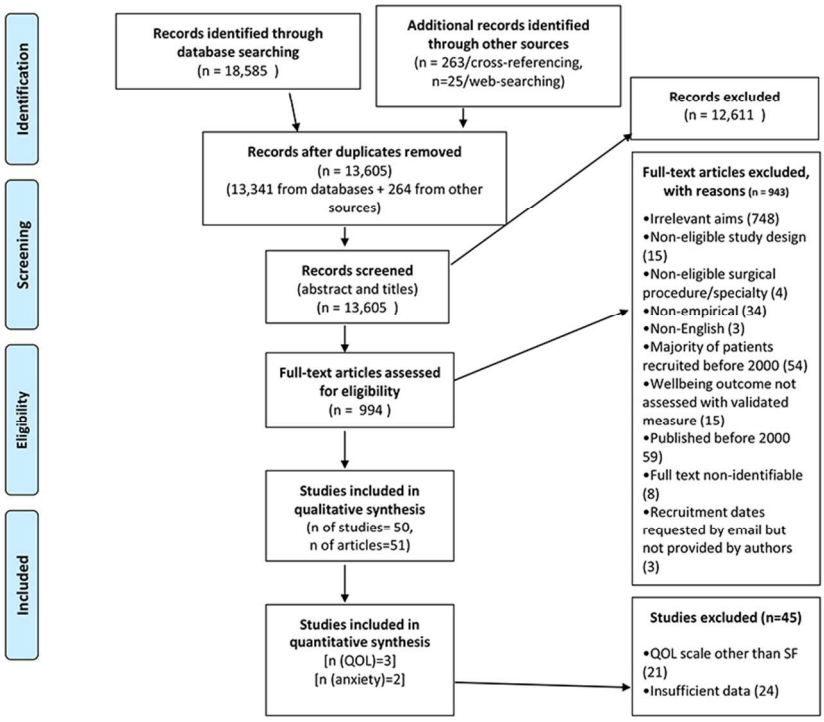
***Study controlled for patients' preoperative wellbeing**

[21] A validated instrument assessing pain, symptoms, activities, social life and emotional state in patients with vascular disease

Table 4: Domains of patients' wellbeing that were significantly affected by surgical complications

		Studies																														
Measures		Bruns	Liu	Bloemen	Siassi	Rutegard	Pittman	Sharma	Avery	Le Grande	Nguyen [b]	Viklund	Delaney	Kalliomaki	Hawn	Anthony	Chang	Douma	Kement	Targarona	Peric	El Baz	Deaton	Ferguson	Tully	Gjeilo	Jideus	Kinney	Polese	Rea	Bitzer	Jarvinen	Moller
Short Form scales (e.g. SF-36, SF-12 RAND-36)	Physical-Component	✓			✓					✓					✓			✓	✓				✓									✓	
	Mental Component									✓					✓				✓				✓										
	Physical functioning													✓												✓	✓	✓				✓	✓
	Bodily pain													✓					✓							✓		✓	✓	✓	✓		
	Role physical													✓												✓			✓	✓	✓	✓	
	Role emotional													✓															✓				
	General health													✓					✓							✓	✓		✓	✓		✓	✓
	Mental health													✓								✓				✓			✓	✓			
	Social functioning													✓					✓							✓	✓		✓	✓			
	Vitality													✓					✓			✓				✓		✓		✓			✓
EORTC QLQ-C30+	Physical Functioning			✓		✓			✓	✓		✓						✓						✓									
	Global QOL					✓				✓		✓																					
	Social Functioning								✓																								
	Fatigue			✓		✓																											
	Role functioning					✓			✓																								
	Pain			✓																												
	Weight loss			✓																												

	Dyspnea					✓																										
	Nausea-Vomiting					✓			✓																							
	Coughing						✓																									
	Defecation																		✓													
VascuQOL	Total QOL										✓																					
GIQLI	Total QOL																			✓												
mCOH-QOL	Total QOL		✓																													
	Physical QOL						✓																									
	Social QOL						✓																									
FACT-C	Total QOL													✓																		
	Physical wellbeing							✓						✓																		
	Social wellbeing													✓																		
	Cancer concerns													✓																		
CGQL	Total QOL											✓																				
WHOQOL-BREF	Physical domain														✓																	
	Pain & discomfort														✓																	
	Activities of daily living														✓																	
IBDQ	Social functioning															✓																
NHP	Social isolation																			✓												
	Sleep																			✓												
	Pain																			✓												
HADS & DASS	Anxiety							✓					✓											✓								
	Depression							✓					✓																			
PANAS	Negative affect							✓																								
MRS	Negative mood							✓																								



PRISMA diagram
84x63mm (300 x 300 DPI)

Supplementary materials for manuscript entitled:

Surgical complications and their impact on patients' psychosocial wellbeing: A systematic review and meta-analysis

Supplementary material 1: Search strategies

Embase

1. exp mental stress/
2. exp emotion/
3. exp depression/
4. exp ANXIETY/
5. exp posttraumatic stress disorder/
6. exp "quality of life"/
7. exp wellbeing/
8. 1 or 2 or 3 or 4 or 5 or 6 or 7
9. exp surgery/
10. exp complication/
11. 9 and 10
12. exp surgery/co [Complication]
13. exp perioperative complication/
14. exp peroperative complication/
15. exp postoperative complication/
16. exp preoperative complication/
17. exp surgical error/
18. exp iatrogenic disease/su [surgery]
19. exp anesthesia complication/
20. exp ANESTHESIA/co [Complication]
21. exp anesthesia/
22. exp complication/
23. 21 and 22
24. 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 23
25. exp patient/
26. adult/
27. female/
28. male/
29. 25 or 26 or 27 or 28
30. 8 and 24 and 29
31. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or awareness or iatrogen* or ((adverse or unfavourable or unfavorable or untoward or undesired) adj (outcome*1 or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
32. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or per-operative or peroperative or intra-operative or intraoperative or intra operative or anesth* or anaesth*).ti,ab.
33. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
34. 31 and 32 and 33
35. 30 or 34
36. limit 35 to (human and English language)

MEDLINE

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Stress, Psychological/
9. exp Emotions/
10. exp Depression/
11. exp Anxiety/
12. exp Stress Disorders, Post-Traumatic/
13. exp "Quality of Life"/
14. 8 or 9 or 10 or 11 or 12 or 13
15. exp Medical Errors/
16. exp Postoperative Complications/
17. exp iatrogenic disease/su [surgery]
18. exp Anesthesia/ae, co [Adverse Effects, Complications]
19. 15 or 16 or 17 or 18
20. 14 and 19
21. exp Patients/
22. exp adult/
23. exp women/
24. exp men/
25. exp research subjects/
26. 21 or 22 or 23 or 24 or 25
27. 14 and 19 and 26
28. 7 or 27
29. limit 28 to (English language and humans)

PsycINFO

1. (psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic or post-traumatic or PTSD or QOL or quality of life or well-being or wellbeing).ti,ab.
2. (surg* or post-operative or postoperative or post operative or peri-operative or perioperative or peri operative or peroperative or per-operative or intra-operative or intraoperative or intra operative or anaesth* or anesth*).ti,ab.
3. (patient* or inpatient* or in-patient* or outpatient* or out-patient* or participant* or women or men).ti,ab.
4. (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1))).ti,ab.
5. ((psycholog* or psychosocial or psycho-social or psychiatr* or emotion* or feeling* or anxiet* or depressi*2 or posttraumatic stress or post-traumatic stress or PTSD or QOL or quality of life or wellbeing or well-being) adj25 (complication*1 or harm or error*1 or poor outcome or iatrogen* or awareness or ((adverse or unfavourable or unfavorable or untoward or undesired or unanticipated) adj (outcome*1or effect*1 or event*1 or incident*1 or reaction*1)))).ti,ab.
6. 2 and 5
7. 2 and 3 and 5
8. exp Psychological Stress/
9. exp emotions/
10. exp "depression (emotion)"/
11. exp Anxiety/
12. exp posttraumatic stress disorder/
13. exp "Quality of Life"/
14. exp well being/
15. 8 or 9 or 10 or 11 or 12 or 13 or 14
16. exp postsurgical complications/
17. exp patients/
18. exp Human Females/
19. exp human males/
20. 17 or 18 or 19
21. 15 and 16 and 20
22. 7 or 21
23. limit 22 to (human and English language)

Supplementary material 2:

Detailed report of meta-analyses on the impact of complications on patients' psychosocial wellbeing

Quality of life

Due to the different measurement tools that were used for the assessment of QOL as well as the different domains that each tool assesses, a meta-analysis was conducted only on the studies that used the SF-tools. These were the most commonly used tools for the assessment of QoL, they are not condition-specific and they use the same measurement scale. Moreover, all of them yield the same summary scores (i.e. physical and mental). [1] A meta-analysis was conducted on each summary score. The effect sizes are expressed as mean differences (MD) on a scale ranging from 0 to 100.

Only three studies provided sufficient data for a meta-analysis on the SF- physical and mental component scores between patients with complications and patients without complications. [2-4] The pooled mean differences between the two groups indicated significantly lower levels of physical and mental quality of life in patients who suffered complications compared to patients without complications (see eTable1).

The estimates of heterogeneity (I^2) were low (<25%).

Anxiety and Depression

Two studies provided sufficient data for a meta-analysis on anxiety levels. [5, 6] Each study used a different scale, therefore the effect sizes are expressed as standardised mean differences (SMD). The pooled SMD for anxiety was not significant indicating a lack of population effect in terms of the complications' impact on patients' anxiety levels. The estimate of heterogeneity was high (I^2=81%), however a sensitivity analysis by the methodological quality of the included studies did not alter the results. A meta-analysis on depression was not possible as only one study provided sufficient data. [6]

Supplementary material 3

eTable1: Results of meta-analyses on the impact of surgical complications on patient psychosocial outcomes

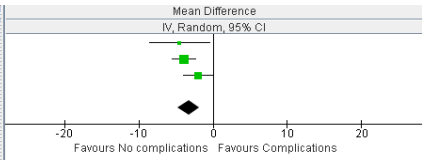
Wellbeing outcome	Sub-score	Comparison	k	N	Z	*P*	MD (SMD/anxiety)	95% CI	I^2
Quality of life (SF-scales)	Physical component	Complications vs. No complications	3	244 1638	4.51	0.00001	-3.28	-4.71, -1.86	20%
	Mental component	Complications vs. No complications	3	244 1638	6.52	0.00001	-3.82	-4.97, -2.67	0%
Anxiety		Complications vs. No complications	2	148 262	1.12	0.26	0.27	-0.21, 0.75	81%

Supplementary material 4:

Forest plots of meta-analyses on the impact of surgical complications on patient psychosocial outcomes

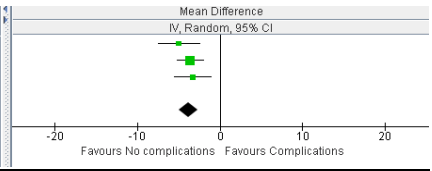
SF Physical summary score (SF PCS)

Study or Subgroup	Complications			No complications			Weight	Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
20-Hawn	41.2	16.0186	105	45.7	52.9351	1479	11.3%	-4.50 [-8.58, -0.42]
28-Kement	53.97	2.22	9	57.91	1.63	19	51.5%	-3.94 [-5.57, -2.31]
39-Deaton	41	9	130	43	8	140	37.2%	-2.00 [-4.04, 0.04]
Total (95% CI)			244			1638	100.0%	-3.28 [-4.71, -1.86]
Heterogeneity: Tau² = 0.34; Chi² = 2.49, df = 2 (P = 0.29); I² = 20%								
Test for overall effect: Z = 4.51 (P < 0.00001)								



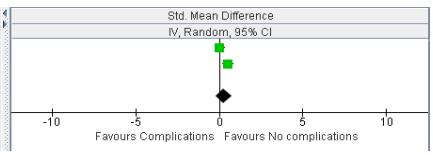
SF Mental summary score (SF MCS)

Study or Subgroup	Complications			No complications			Weight	Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
39-Deaton	43	11	130	48	10	140	20.9%	-5.00 [-7.51, -2.49]
28-Kement	47.17	1.96	9	50.79	2.09	19	52.3%	-3.62 [-5.21, -2.03]
20-Hawn	47.1	10.3346	105	50.4	19.6056	1479	26.9%	-3.30 [-5.51, -1.09]
Total (95% CI)			244			1638	100.0%	-3.82 [-4.97, -2.67]
Heterogeneity: Tau² = 0.00; Chi² = 1.12, df = 2 (P = 0.57); I² = 0%								
Test for overall effect: Z = 6.52 (P < 0.00001)								



Anxiety

Study or Subgroup	Complications			No complications			Weight	Std. Mean Difference
	Mean	SD	Total	Mean	SD	Total		IV, Random, 95% CI
18-Kalliomaki	9.18	8.36	56	8.98	6.46	170	49.7%	0.03 [-0.27, 0.33]
44-Tully	4.08	3.45	92	2.56	2.27	92	50.3%	0.52 [0.22, 0.81]
Total (95% CI)			148			262	100.0%	0.27 [-0.21, 0.75]
Heterogeneity: Tau² = 0.10; Chi² = 5.19, df = 1 (P = 0.02); I² = 81%								
Test for overall effect: Z = 1.12 (P = 0.26)								



References

1. Ware JE, Kosinski M. SF-36 physical & mental health summary scales: a manual for users of version 1: Quality Metric Inc; 2001.
2. Deaton C, Thourani V. Patients with type 2 diabetes undergoing coronary artery bypass graft surgery: Predictors of outcomes. *Eur J Cardiovasc Nur* 2009; **8(1)**: 48-56.
3. Hawn MT, Itani KM, Giobbie-Hurder A, McCarthy Jr M, Jonasson O, Neumayer LA. Patient-reported outcomes after inguinal herniorrhaphy. *Surgery* 2006; **140(2)**: 198-205.
4. Kement M, Karabulut M, Gezen FC, Demirbas S, Vural S, Oncel M. Mild and severe anal incontinence after lateral internal sphincterotomy: Risk factors, postoperative anatomical findings and quality of life. *Eur Surg Res* 2011; **47**(1): 26-31.
5. Kalliomaki ML, Sandblom G, Gunnarsson U, Gordh T. Persistent pain after groin hernia surgery: A qualitative analysis of pain and its consequences for quality of life. *Acta Anaesth Scand* 2009; **53(2)**: 236-46.
6. Tully PJ, Bennetts JS, Baker RA, McGavigan AD, Turnbull DA, Winefield HR. Anxiety, depression, and stress as risk factors for atrial fibrillation after cardiac surgery. *Heart Lung* 2011; **40(1)**: 4-11.

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Not available
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Suppl. Materials
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7-8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Suppl. Materials

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8-9

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9 & Fig 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Tables 1-4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Tables 1-3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Suppl. Materials and Tables 1-3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Suppl. Materials
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17-18

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	18

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