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Feasibility of administrative data for studying complications after hip fracture surgery

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FEASIBILITY OF ADMINISTRATIVE DATA FOR STUDYING COMPLICATIONS AFTER HIP FRACTURE SURGERY

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ABSTRACT

Purpose: There is limited information on the occurrence of complications after hip fracture surgery. This may be due to lack of information in administrative databases on complications. This study sought to determine the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying the Agency for Healthcare Research and Quality Patient Safety Indicator 4 case-finding tool.

Methods: We obtained Canadian Institute for Health Information discharge abstracts for patients 65 years or older who were surgically treated for non-pathological first hip fracture between January 1, 2004 and December 31, 2012 in Canada, except for Quebec. We applied specifications of Agency for Healthcare Research and Quality Patient Safety Indicators 04, version 5.0 to identify complications from hip fracture discharge abstracts.

Results: From 153,613 patients admitted with hip fracture, we identified 12,383 (8.1%) patients with at least one postsurgical complication. From patients with postsurgical complications, we identified 3,066 (24.8%) patient admissions to intensive care unit. Overall, 7,487 (4.9%) patients developed pneumonia, 1,664 (1.1%) developed shock/myocardial infarction, 651 (0.4%) developed sepsis, 1,862 (1.1%) developed deep venous thrombosis/pulmonary embolism, and 1,919 (1.3%) developed gastrointestinal hemorrhage/acute ulcer.

Conclusions: We report 8.1% of patients developed at least one in-hospital complications after hip fracture surgery in Canada between 2004 and 2012 and submit that the the Agency for Healthcare Research and Quality Patient Safety Indicator 4 case-finding tool could be considered to identify these serious complications for evaluation of postsurgical care after hip fracture.

Keywords: Hip fracture, complications, patient safety indicators, surgery

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study includes all hip fractures (over 150,000) recorded in Canada over an 8 year period.
- Compared with a prospective study, observational design is more suitable for determining population based proportions of postsurgical complications.
- This study presents the first application of a case-finding tool to identify five serious but treatable complications after an unplanned procedure - hip fracture surgery.
- The case-finding tool focuses on five serious but treatable postsurgical complications, the frequency of all complications after hip fracture will be higher than reported here.

INTRODUCTION

Surgery for hip fracture carries a significant risk of death with 7% dying in-hospital.[1] This mortality risk depends on characteristics of patients, injury and treatment. The occurrence of in-hospital death is also associated with postsurgical complications.[2] Over 20 years ago, Silber and colleagues suggested in-hospital death following postsurgical complications as an indicator of quality of care.[3] They based this on the premise that postsurgical complications reflect characteristics of the patient and their injury, whereas death from such complications reflects the process of care.[3, 4] Miller advanced this approach through the concept of preventable death after serious but treatable complications.[5]

Yet, there is limited information on the occurrence of serious but treatable complications after hip fracture surgery.[6, 7] One obstacle in understanding the role of complications after hip fracture surgery has been the lack of information in administrative databases about events that occur during the hospital stay.[8] However, the US Agency for Healthcare Research and Quality (AHRQ) developed Patient Safety Indicator 4 (PSI-4), *Death among Surgical Inpatients with Serious Treatable Complications,* and a case-finding tool for screening diagnosis and procedure codes in discharge

abstracts of planned surgical procedures.[9] This tool allowed research on the quality of postsurgical care leading to the US Patient Safety and Quality Improvement Act of 2005.[10] This study sought to determine the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying the AHRQ PSI-4 case-finding tool. The University of British Columbia Behavioral Research Ethics Board approved this study.

METHODS

Data source

We obtained all discharge abstracts for patients 65 years or older who were surgically treated for non-pathological first hip fracture between January 1, 2004 and December 31, 2012 in all Canadian hospitals, except for the province of Quebec which does not participate in this database. Multiple abstracts linked by hospital transfers for the same patient were combined in one care episode.[11] We selected only patients who stayed at least one day after surgery.

We converted CIHI diagnosis and procedure codes from ICD-10-Canada (CA)/ Canadian Classification of Health Intervention (CCI)/Canadian Classification of Procedure (CCP) to ICD-9-Clinical Modification (CM) codes, and discharge dispositions to Uniform Hospital Discharge Data Set (UHDDS).

Outcomes

The primary outcome was the occurrence of at least one postsurgical complications listed in AHRQ PSI-4: shock/myocardial infarction, sepsis, pneumonia, deep venous thrombosis/pulmonary embolism, and gastrointestinal hemorrhage/acute ulcer.[9] We also report the occurrence of each postsurgical complication. We extended the AHRQ specifications to include all older adults, urgent admissions for hip fracture, and surgeries within 4 days of admission (Figure 1, Table 1).

Table 1. Specifications for Identification of Serious Treatable Complications After Hip Fracture Surgery.

Complication*	**Definition†**
Shock/MI	**Numerator**: secondary diagnosis code for shock/MI‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for shock, MI, hemorrhage, or GI hemorrhage; any listed procedure code for lung cancer resection; major diagnostic category 4 (diseases/disorder of respiratory system) or 5 (diseases/disorders of circulatory system); discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
Sepsis	**Numerator**: secondary diagnosis code for sepsis‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for sepsis or infection; any listed diagnosis or procedure code for immunocompromised state; length of stay < 4 days; or discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
Pneumonia	**Numerator**: secondary diagnosis code for pneumonia‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for pneumonia or respiratory complications; any listed diagnosis code for viral pneumonia, influenza or immunocompromised state; any listed procedure code for lung cancer; major diagnostic category 4 (diseases/disorder of respiratory system) or discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
DVT/PE	**Numerator**: secondary diagnosis code for DVT/PE‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for DVT/PE; discharge disposition of transfer to acute care; missing discharge disposition, age, or sex
GI hemorrhage/ acute ulcer	**Numerator**: secondary diagnosis code for GI hemorrhage/acute ulcer‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for GI hemorrhage, acute ulcer, alcoholism, or anemia; major diagnostic category 6 (diseases/disorder of digestive system) or 7 (diseases/disorders of hepatobiliary system and pancreas); discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex

MI – myocardial infarction; DVT –deep venous thrombosis; PE –pulmonary embolism; GI – gastrointestinal

* identified from complications listed in AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications

† modified from AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications

‡identified from secondary ICD-9-CM diagnosis codes listed in AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications, *Death Rate among Surgical Inpatients with Serious Treatable Complications*

Diagnosis-related groups

To apply the AHRQ case-finding tool, the diagnosis codes from the abstracts must first be assigned to a diagnosis-related group (DRG). The DRG classification system categorizes the discharge abstracts into 'buckets' according to hospital resource use and clinical homogeneity. We assigned the abstracts to a DRG according to post-admission diagnosis codes, procedure codes, age, sex, discharge disposition and year of discharge.[12] DRGs were further aggregated into major diagnostic categories (MDC) according to the principal diagnosis of admission.

We assigned DRGs and MDCs to the discharge abstracts using a MS Access 2003 application (www.drggroupers.net), DRG Masks files f20 (October1, 2002 – September 30, 2003) to f30 (October 1, 2012 – September 30, 2013), and select CIHI data fields (Figure 1).[12] This application accounted for changes in DRG and MDC classification over time. We set the DRG present on admission flag according to the CIHI diagnosis type: 'yes' for type 1 and 5, 'unspecified' for type M, 2, 3, 4, 6, 7, 8, 9, 0, W, X, and Y. We set the DRG hospital acquired complications flag to 'false'. We used the CIHI most responsible diagnosis for admission as the principal diagnosis for the DRG.

We applied the following pre-DRG exclusions: missing principal procedure or discharge date, unspecified sex, elective admission with principal procedure more than 4 days after admission, discharge after September 30, 2013, and where conversion from ICD-10-CA/CCI/CCP to ICD-9-CM was not possible.

Analysis

Patient characteristics were expressed as frequencies and proportions. The number of discharges with postsurgical complications, expressed as a proportion of all discharges was used to calculate the incidence of complications after hip fracture surgery. In addition, we established the number of discharges with admission to intensive care unit after hip fracture surgery and calculated the proportion of admissions to intensive care among discharges with the studied postsurgical complications.

RESULTS

Patient characteristics

We studied 153,613 surgically-treated patients after the application of pre-DRG exclusions (n = 131). The majority of patients were women (73.4%). Age was similarly distributed for those aged 65 to 84 (57.1%) and more than 85 (42.9%) years. Fracture type was similarly distributed between transcervical (52.0%) and trochanteric (48.0%) fractures. Major comorbidity was reported for 27.0%, with cardiac dysrhythmias being the most prevalent (9.4%).

DRG assignment

In total 87% of patients were assigned a DRG of *hip and femur* procedures or *major joint*. The remaining patients were assigned a DRG of *pathological fractures* (7%), *multiple major joint procedures* (2%), or *other* (4%). In total 94% of patients were assigned MDC of 08 (Musculoskeletal System and Connective Tissue). The remaining patients were assigned MDC of 23 (3%), 24 (1%) or other (2%).

Complications and admissions to intensive care unit

From 153,613 patients, we identified 12,383 (8.1%) patients with at least one postsurgical complication and 11,807 (7.7%) admissions to intensive care unit during acute hospitalization for first hip fracture. Overall, 7,487 (4.9%) patients developed pneumonia, 1,664 (1.1%) developed shock/myocardial

infarction, 651 (0.4%) developed sepsis, 1,862 (1.1%) developed deep venous thrombosis/pulmonary embolism, and 1,919 (1.3%) developed gastrointestinal hemorrhage/acute ulcer. Among patients with postsurgical complications, 3,066 (24.8%) had admissions to intensive care unit.

DISCUSSION

Main findings

One in twelve patients had at least one complication on their discharge abstract after hip fracture surgery in Canada between 2004 and 2012, with pneumonia being the most prevalent (60.5%). One quarter of surgically-treated patients with complications required intensive care treatment during their inpatient stay.

Comparison with other studies

We examined the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying specifications of AHRQ Quality Indicator Research Version 5.0 for PSI-4. In developing these specifications, the AHRQ subjected the list of complications and their definitions to rigorous clinical review, evaluation of reliability, and validation.[13] Further, these specifications are continually revised with some complications from the PSI-4 list made available as separate safety indicators, for example deep venous thrombosis/pulmonary embolism (PSI-12) and sepsis (PSI-13).[12]

In particular, we report the extent to which our estimated incidence of complication after hip fracture surgery were similar to the United States (US) National Trauma Data Bank (NTDB) where postsurgical complications are coded prospectively.[14] Between January 1, 2012 and December 31, 2012 56,808 patients 65 years and older were admitted to a US NTDB acute hospital with a diagnosis codes of hip fracture ICD-9 820. In total 7.7% patients developed postsurgical complications during hospitalization

for first hip fracture. Therefore, our application of the AHRQ PSI-4 to Canadian hospital discharge abstracts revealed similar rates of complications among adult surgical inpatients in the US.

In the current study we report pneumonia as the most frequent complication after hip fracture surgery in Canada. This finding is similar to a UK study where chest infection was the most frequent postsurgical complication.[15] Pneumonia is associated with readmission and mortality after hip fracture surgery.[16] A recent study reported that over two thirds of 30 day mortality occurrences after hip fracture surgery were due to pneumonia and acute myocardial infarction.[16] An autopsy study of more than 500 deaths after hip fracture surgery reported bronchopneumonia and myocardial infarction as the principal causes of death.[17] In the current study a similar proportion of patients developed shock, myocardial infarction, deep venous or pulmonary embolism, gastrointestinal bleeding or ulcers after hip fracture surgery. Less than 1% of patients developed postsurgical sepsis.

Others reported that death after serious but treatable complications could be considered as a quality indicator for postsurgical care. Studies have shown an association between complications and other measures of hospital quality including mortality, length of stay, and readmissions.[3, 8, 18, 19]

Limitations

To account for differences in coding methods between the United States and Canada, we converted ICD-10-CA diagnosis and CCI/CCP procedure codes to ICD-9-CM and discharge dispositions to UHDDS.We acknowledge the conversion to a less specific coding system leads to losses in precision. We do not believe pre-DRG exclusions would bias results as they represented less than 1% of the total population.

We focused only on five postsurgical complications after hip fracture surgery listed in the PSI-4 and admissions to the intensive care unit. The reason for admission to intensive care was not available. Our

data showed that three quarters of abstracts with admissions to the intensive care unit did not have the studied complications. These admissions were likely due to other conditions, such as unplanned intubation, wound infection, acute kidney injury, acute respiratory distress syndrome and cerebrovascular accident.[15] Future studies may need to consider a composite outcome of postsurgical complications and intensive care admissions in investigating quality of postsurgical care.

CONCLUSIONS

We report the incidence of 8.1% for in-hospital complications among patients who underwent hip fracture surgery in Canada between 2004 and 2012 and submit that the AHRQ PSI-4 case-funding tool could be considered to identify these serious complications for evaluation of postsurgical care after hip fracture.

FUNDING SOURCE

This research was funded by the Canadian Institute for Health Research. This funder had no role in the design of this study, execution, analyses, data interpretation or decision to submit results for publication.

COMPETING INTERESTS

The authors declare that (1) Boris Sobolev, Pierre Guy and the Collaborative have received grants from the Canadian Institutes of Health Research related to this work. (2) Pierre Guy also receives funding from the Natural Sciences and Engineering Research Council of Canada, the Canadian Foundation for Innovation and the British Columbia Specialists Services Committee for work around hip fracture care not related to this manuscript. He has also received fees from the BC Specialists Services Committee (for a provincial quality improvement project on redesign of hip fracture care) and from Stryker Orthopedics (as a product development consultant). He is a board member and shareholder in Traumis Surgical Systems Inc. and a board member for the Canadian Orthopedic Foundation. He also serves on

the speakers' bureaus of AO Trauma North America and Stryker Canada. (3)Suzanne Morin reports research grants from Amgen Canada, and from Merck, personal fees from Amgen Canada outside the submitted work. (4) Katie Sheehan is a postdoctoral fellow whose salary is paid by Canadian Institutes of Health Research funding related to this work.

AUTHORS' CONTRIBUTIONS

All authors contributed to the conception and design of the study. In addition KJS, BS, MT, LK, SS, PG contributed to the acquisition and the analysis of data. KJS, BS, PG, LK, PB, JB, SNM, DG, SJ, EB, JMS, and LB contributed to the interpretation of the analysis. KJS and BS drafted the manuscript. All authors critically revised the manuscript. All authors approved the final version for submission.

DATA SHARING STATEMENT

We studied patient records that were anonymized and de-identified by a third party, the Canadian Institute for Health Information, an organization which provides researchers access to data on Canadian residents. Data are available from the Canadian Institute for Health Information for researchers who meet the criteria for access to confidential data.

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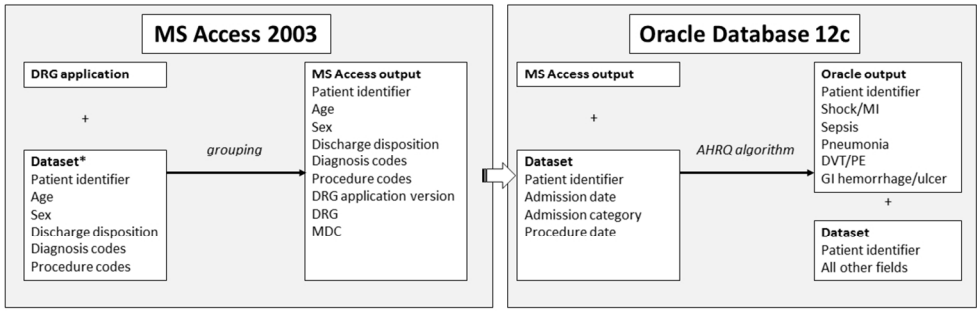

Data model for identifying complications from the Agency for Healthcare Research and Quality's Patient Safety Indicator 04.

MS = Microsoft; DRG = Diagnosis realted grouper; MDC = Major diagnostic categories; PSI = patient safety indicator.

*After pre-grouper exclusions

Figure 1
338x110mm (96 x 96 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Completed	Page Number	Section
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y	2	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y	2	Abstract
Introduction					
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y	3	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Y	4	Introduction
Methods					
Study design	4	Present key elements of study design early in the paper	Y	4-6	Methods: Data source Diagnosis related groups
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y	4	Methods: Data source
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Y	4-5	Methods: Data source, Table 1
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA	NA	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers.	Y	4	Methods: Outcomes, Table 1

		Give diagnostic criteria, if applicable			
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y	4-7	Methods: Data source, Outcomes, Table 1, Diagnosis-related groups
Bias	9	Describe any efforts to address potential sources of bias	NA	NA	NA
Study size	10	Explain how the study size was arrived at	Y	4	Methods: Data source
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y	7	Methods: Analysis
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y	7	Methods: Analysis
		(*b*) Describe any methods used to examine subgroups and interactions	NA	NA	NA
		(*c*) Explain how missing data were addressed	NA	NA	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	NA	NA	NA
		(*e*) Describe any sensitivity analyses	NA	NA	NA
Results					
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y	4, 7	Methods: Data source; Results: Patient characteristics
		(b) Give reasons for non-participation at each stage	NA	NA	NA
		(c) Consider use of a flow diagram	Not used	Not used	Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y	7	Results: Patient characteristics

		(b) Indicate number of participants with missing data for each variable of interest	NA	NA	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Y	4	Methods: Data source, Outcomes
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Y	7	Results
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA	NA	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	NA	NA	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Y	7	Results
		(*b*) Report category boundaries when continuous variables were categorized	NA	NA	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	NA	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	NA	NA
Discussion					
Key results	18	Summarise key results with reference to study objectives	Y	8	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y	9	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y	8-10	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y	8-9	Discussion
Other information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y	10	Funding source

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ABSTRACT

Purpose: There is limited information in administrative databases on the occurrence of serious but treatable complications after hip fracture surgery. This study sought to determine the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying the Agency for Healthcare Research and Quality Patient Safety Indicator 4 case-finding tool.

Methods: We obtained Canadian Institute for Health Information discharge abstracts for patients 65 years or older who were surgically treated for non-pathological first hip fracture between January 1, 2004 and December 31, 2012 in Canada, except for Quebec. We applied specifications of Agency for Healthcare Research and Quality Patient Safety Indicators 04, version 5.0 to identify complications from hip fracture discharge abstracts.

Results: From 153,613 patients admitted with hip fracture, we identified 12,383 (8.1%) patients with at least one postsurgical complication. From patients with postsurgical complications, we identified 3,066 (24.8%) patient admissions to intensive care unit. Overall, 7,487 (4.9%) patients developed pneumonia, 1,664 (1.1%) developed shock/myocardial infarction, 651 (0.4%) developed sepsis, 1,862 (1.1%) developed deep venous thrombosis/pulmonary embolism, and 1,919 (1.3%) developed gastrointestinal hemorrhage/acute ulcer.

Conclusions: We report 8.1% of patients developed at least one in-hospital complications after hip fracture surgery in Canada between 2004 and 2012 and submit that the the Agency for Healthcare Research and Quality Patient Safety Indicator 4 case-finding tool could be considered to identify these serious complications for evaluation of postsurgical care after hip fracture.

Keywords: Hip fracture, complications, patient safety indicators, surgery

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study includes all hip fractures (over 150,000) recorded in Canada over an 8 year period.
- Compared with a prospective study, observational design is more suitable for determining population based proportions of postsurgical complications.
- This study presents the first application of a case-finding tool to identify five serious but treatable complications after an unplanned procedure - hip fracture surgery.
- The case-finding tool focuses on five serious but treatable postsurgical complications, the frequency of all complications after hip fracture will be higher than reported here.

INTRODUCTION

Surgery for hip fracture carries a significant risk of death with 7% dying in-hospital.[1] This mortality risk depends on characteristics of patients, injury and treatment. The occurrence of in-hospital death is also associated with postsurgical complications.[2] Over 20 years ago, Silber and colleagues suggested in-hospital death following postsurgical complications as an indicator of quality of care.[3] They based this on the premise that postsurgical complications reflect characteristics of the patient and their injury, whereas death from such complications reflects the process of care.[3,4] Miller advanced this approach through the concept of preventable death after serious but treatable complications.[5]

Yet, there is a lack of information in administrative databases on the occurrence of serious but treatable complications after hip fracture surgery.[6-8] This makes it difficult to evaluate the effects of care delivery on the risk of postsurgical complications and ensuing in-hospital death nationally. However, the US Agency for Healthcare Research and Quality (AHRQ) developed Patient Safety Indicator 4 (PSI-4), *Death among Surgical Inpatients with Serious Treatable Complications,* and a case-finding tool for screening diagnosis and procedure codes in discharge abstracts of planned surgical procedures.[9]

This tool allowed research on the quality of postsurgical care leading to the US Patient Safety and Quality Improvement Act of 2005.[10] This study sought to determine the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying the AHRQ PSI-4 case-finding tool. The University of British Columbia Behavioral Research Ethics Board approved this study.

METHODS

Data source

We obtained all discharge abstracts for patients 65 years or older who were surgically treated for non-pathological first hip fracture between January 1, 2004 and December 31, 2012 in all Canadian hospitals, except for the province of Quebec which does not participate in this database. Multiple abstracts linked by hospital transfers for the same patient were combined in one care episode.[11] We selected only patients who stayed at least one day after surgery.

We converted Canadian Institute for Health Information (CIHI) diagnosis and procedure codes from ICD-10-Canada (CA)/ Canadian Classification of Health Intervention (CCI)/Canadian Classification of Procedure (CCP) to ICD-9-Clinical Modification (CM) codes, and discharge dispositions to Uniform Hospital Discharge Data Set (UHDDS) (Supplementary File).

Outcomes

The primary outcome was the occurrence of at least one postsurgical complications listed in AHRQ PSI-4: shock/myocardial infarction, sepsis, pneumonia, deep venous thrombosis/pulmonary embolism, and gastrointestinal hemorrhage/acute ulcer.[9] We extended the AHRQ specifications to include all older adults, urgent admissions for hip fracture, and surgeries within 4 days of admission (Figure 1, Table 1).

Table 1. Specifications for Identification of Serious Treatable Complications After Hip Fracture Surgery.

Complication*	**Definition†**
Shock/MI	**Numerator**: secondary diagnosis code for shock/MI‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for shock, MI, hemorrhage, or GI hemorrhage; any listed procedure code for lung cancer resection; major diagnostic category 4 (diseases/disorder of respiratory system) or 5 (diseases/disorders of circulatory system); discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
Sepsis	**Numerator**: secondary diagnosis code for sepsis‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for sepsis or infection; any listed diagnosis or procedure code for immunocompromised state; length of stay < 4 days; or discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
Pneumonia	**Numerator**: secondary diagnosis code for pneumonia‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for pneumonia or respiratory complications; any listed diagnosis code for viral pneumonia, influenza or immunocompromised state; any listed procedure code for lung cancer; major diagnostic category 4 (diseases/disorder of respiratory system) or discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex
DVT/PE	**Numerator**: secondary diagnosis code for DVT/PE‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for DVT/PE; discharge disposition of transfer to acute care; missing discharge disposition, age, or sex
GI hemorrhage/ acute ulcer	**Numerator**: secondary diagnosis code for GI hemorrhage/acute ulcer‡ **Denominator**: surgical discharge, for patients aged ≥65 years with ICD-9-CM code for hip fracture surgery; and surgery within 4 days of admission or urgent admission type **Exclude cases**: principal diagnosis for GI hemorrhage, acute ulcer, alcoholism, or anemia; major diagnostic category 6 (diseases/disorder of digestive system) or 7 (diseases/disorders of hepatobiliary system and pancreas); discharge disposition of transfer to acute care; or missing discharge disposition, age, or sex

MI – myocardial infarction; DVT –deep venous thrombosis; PE –pulmonary embolism; GI – gastrointestinal

* identified from complications listed in AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications

† modified from AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications

‡identified from secondary ICD-9-CM diagnosis codes listed in AHRQ QI Research Version 5.0, Patient Safety Indicators 04, Technical Specifications*, Death Rate among Surgical Inpatients with Serious Treatable Complications*

Diagnosis-related groups

To apply the AHRQ case-finding tool, the diagnosis codes from the abstracts must first be assigned to a diagnosis-related group (DRG). The DRG classification system categorizes the discharge abstracts into 'buckets' according to hospital resource use and clinical homogeneity. We assigned the abstracts to a DRG according to post-admission diagnosis codes, procedure codes, age, sex, discharge disposition and year of discharge.[12] DRGs were further aggregated into major diagnostic categories (MDC) according to the principal diagnosis of admission.

We assigned DRGs and MDCs to the discharge abstracts using a MS Access 2003 application (www.drggroupers.net), DRG Masks files f20 (October1, 2002 – September 30, 2003) to f30 (October 1, 2012 – September 30, 2013), and select CIHI data fields (Figure 1).[12] This application accounted for changes in DRG and MDC classification over time. We set the DRG present on admission flag according to the CIHI diagnosis type: 'yes' for type 1 and 5, 'unspecified' for type M, 2, 3, 4, 6, 7, 8, 9, 0, W, X, and Y. We set the DRG hospital acquired complications flag to 'false'. We used the CIHI most responsible diagnosis for admission as the principal diagnosis for the DRG.

We applied the following pre-DRG exclusions: missing principal procedure or discharge date, unspecified sex, elective admission with principal procedure more than 4 days after admission, discharge after September 30, 2013, and where conversion from ICD-10-CA/CCI/CCP to ICD-9-CM was not possible.

Analysis

Patient characteristics were expressed as frequencies and proportions. The number of discharges with postsurgical complications, expressed as a proportion of all discharges was used to calculate the incidence of complications after hip fracture surgery. In addition, we established the number of discharges with admission to intensive care unit after hip fracture surgery and calculated the proportion of admissions to intensive care among discharges with the studied postsurgical complications.

RESULTS

Patient characteristics

We studied 153,613 surgically-treated patients after the application of pre-DRG exclusions (n = 131). The majority of patients were women (73.4%). The median age was 84 years (Interquartile range 65 - 110). Fracture type was similarly distributed between transcervical (52.0%) and trochanteric (48.0%) fractures. Overall 27.0% had at least one major comorbidity (heart failure, chronic obstructive pulmonary disease, ischaemic heart disease, hypertension, cardiac arrhythmia or diabetes). Cardiac arrhythmias including supra ventricular tachycardia (ICD-10-CA 147), atrial fibrillation and flutter (ICD-10-CA 148) and other such as ventricular premature and atrial premature depolarization (ICD-10-CA 149) were the most prevalent (9.4%).

DRG assignment

In total 87% of patients were assigned a DRG of *hip and femur* procedures or *major joint*. The remaining patients were assigned a DRG of *pathological fractures* (7%), *multiple major joint procedures* (2%), or *other* (4%). In total 94% of patients were assigned MDC of 08 (Musculoskeletal System and Connective Tissue). The remaining patients were assigned MDC of 23 (3%), 24 (1%) or other (2%).

Complications and admissions to intensive care unit

From 153,613 patients, we identified 12,383 (8.1%) patients with at least one postsurgical complication and 11,807 (7.7%) admissions to intensive care unit during acute hospitalization for first hip fracture. Overall, 7,487 (4.9%) patients developed pneumonia, 1,664 (1.1%) developed shock/myocardial infarction, 651 (0.4%) developed sepsis, 1,862 (1.1%) developed deep venous thrombosis/pulmonary embolism, and 1,919 (1.3%) developed gastrointestinal hemorrhage/acute ulcer (Figure 2). Among patients with postsurgical complications, 3,066 (24.8%) had admissions to intensive care unit.

DISCUSSION

Main findings

One in twelve patients had at least one complication on their discharge abstract after hip fracture surgery in Canada between 2004 and 2012, with pneumonia being the most prevalent (60.5%). One quarter of surgically-treated patients with complications required intensive care treatment during their inpatient stay.

Comparison with other studies

We examined the feasibility of identifying the occurrence of serious but treatable complications after hip fracture surgery from discharge abstracts by applying specifications of AHRQ Quality Indicator Research Version 5.0 for PSI-4. In developing these specifications, the AHRQ subjected the list of complications and their definitions to rigorous clinical review, evaluation of reliability, and validation.[8] Further, these specifications are continually revised with some complications from the PSI-4 list made available as separate safety indicators, for example deep venous thrombosis/pulmonary embolism (PSI-12) and sepsis (PSI-13).[12]

In particular, we report the extent to which our estimated incidence of complication after hip fracture surgery were similar to the United States (US) National Trauma Data Bank (NTDB) where postsurgical

complications are coded prospectively.[13] Between January 1, 2012 and December 31, 2012 56,808 patients 65 years and older were admitted to a US NTDB acute hospital with a diagnosis codes of hip fracture ICD-9 820. In total 7.7% patients developed postsurgical complications during hospitalization for first hip fracture. Therefore, our application of the AHRQ PSI-4 to Canadian hospital discharge abstracts revealed similar rates of complications among adult surgical inpatients in the US.

In the current study we report pneumonia as the most frequent complication after hip fracture surgery in Canada. This finding is similar to a UK study where chest infection was the most frequent postsurgical complication.[14] Pneumonia is associated with readmission and mortality after hip fracture surgery.[15] A recent study reported that over two thirds of 30 day mortality occurrences after hip fracture surgery were due to pneumonia and acute myocardial infarction.[15] An autopsy study of more than 500 deaths after hip fracture surgery reported bronchopneumonia and myocardial infarction as the principal causes of death.[16] In the current study a similar proportion of patients developed shock, myocardial infarction, deep venous or pulmonary embolism, gastrointestinal bleeding or ulcers after hip fracture surgery. Less than 1% of patients developed postsurgical sepsis.

Others reported that death after serious but treatable complications could be considered as a quality indicator for postsurgical care. Studies have shown an association between complications and other measures of hospital quality including mortality, length of stay, and readmissions.[3,8,17,18]

Limitations

Identification of postsurgical complications in administrative databases may vary by the definition of each complication. For example, a search for 'pneumonia' returns over 300 results across 3 medical coding data sets.[19] Whether all these results are applicable to the definition of pneumonia as a complication after hip fracture surgery may be debated. Therefore, we focused on the five postsurgical complications after hip fracture surgery as defined by the PSI-4 to facilitate reproducibility of our

results. We also focused on admissions to the intensive care unit. The reason for admission to intensive care was not available. Our data showed that three quarters of abstracts with admissions to the intensive care unit did not have the studied complications. These admissions were likely due to other conditions, such as unplanned intubation, wound infection, acute kidney injury, acute respiratory distress syndrome and cerebrovascular accident.[14]

To account for differences in coding methods between the United States and Canada, we converted ICD-10-CA diagnosis and CCI/CCP procedure codes to ICD-9-CM and discharge dispositions to UHDDS.We acknowledge the conversion to a less specific coding system leads to losses in precision. We do not believe pre-DRG exclusions would bias results as they represented less than 1% of the total population.

Future research

Here we demonstrated the feasibility of identifying five postsurgical complications in administrative data. Future research should identify additional complications which occur after hip fracture surgery. Future research may also consider a composite outcome of postsurgical complications and intensive care admissions in investigating quality of postsurgical care. Finally, future research should explore the potential associations between patient characteristics, their injury and their care, and the occurrence of postoperative complications and ensuing death.

CONCLUSIONS

We report the incidence of 8.1% for in-hospital complications among patients who underwent hip fracture surgery in Canada between 2004 and 2012 and submit that the AHRQ PSI-4 case-funding tool could be considered to identify these serious complications for evaluation of postsurgical care after hip fracture.

FIGURE LEGENDS

Figure 1: Data model for identifying complications from the Agency for Healthcare Research and Quality's Patient Safety Indicator 04.

MS = Microsoft; DRG = Diagnosis realted grouper; MDC = Major diagnostic categories; PSI = patient safety indicator.
*After pre-grouper exclusions

Figure 2: Complications after hip fracture surgery.

MI =Myocardial infarction; DVT = Deep venous thrombosis; PE = pulmonary embolism; GI = gastrointestinal.

FUNDING SOURCE

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COMPETING INTERESTS

The authors declare that (1) Boris Sobolev, Pierre Guy and the Collaborative have received grants from the Canadian Institutes of Health Research related to this work. (2) Pierre Guy also receives funding from the Natural Sciences and Engineering Research Council of Canada, the Canadian Foundation for Innovation and the British Columbia Specialists Services Committee for work around hip fracture care not related to this manuscript. He has also received fees from the BC Specialists Services Committee (for a provincial quality improvement project on redesign of hip fracture care) and from Stryker Orthopedics (as a product development consultant). He is a board member and shareholder in Traumis Surgical Systems Inc. and a board member for the Canadian Orthopedic Foundation. He also serves on the speakers' bureaus of AO Trauma North America and Stryker Canada. (3)Suzanne Morin reports research grants from Amgen Canada, and from Merck, personal fees from Amgen Canada outside the

submitted work. (4) Katie Sheehan is a postdoctoral fellow whose salary is paid by Canadian Institutes of Health Research funding related to this work.

AUTHORS' CONTRIBUTIONS

All authors contributed to the conception and design of the study. In addition KJS, BS, MT, LK, SS, PG contributed to the acquisition and the analysis of data. KJS, BS, PG, LK, PB, JB, SNM, DG, SJ, EB, JMS, and LB contributed to the interpretation of the analysis. KJS and BS drafted the manuscript. All authors critically revised the manuscript. All authors approved the final version for submission.

DATA SHARING STATEMENT

We studied patient records that were anonymized and de-identified by a third party, the Canadian Institute for Health Information, an organization which provides researchers access to data on Canadian residents. Data are available from the Canadian Institute for Health Information for researchers who meet the criteria for access to confidential data.

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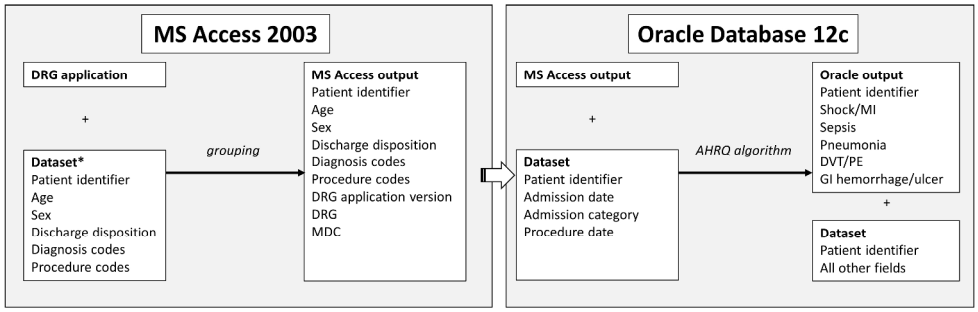

Figure 1: Data model for identifying complications from the Agency for Healthcare Research and Quality's Patient Safety Indicator 04. MS = Microsoft; DRG = Diagnosis realted grouper; MDC = Major diagnostic categories; PSI = patient safety indicator. *After pre-grouper exclusions.

338x109mm (300 x 300 DPI)

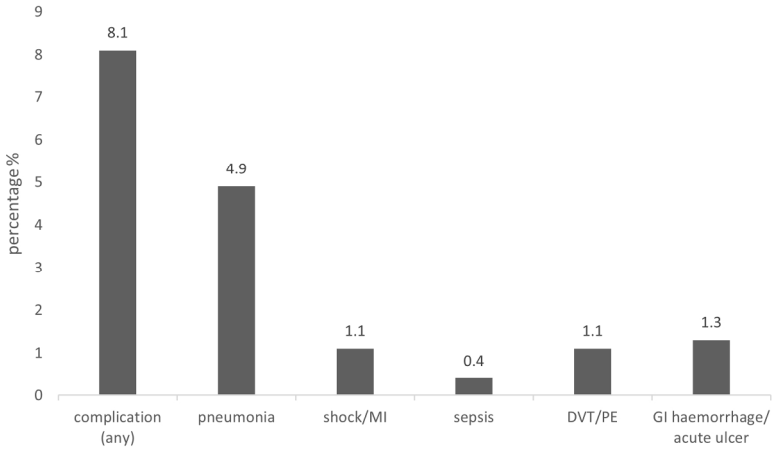

Figure 2: Complications after hip fracture surgery. MI =Myocardial infarction; DVT = Deep venous thrombosis; PE = pulmonary embolism; GI = gastrointestinal.

189x99mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Completed	Page Number	Section
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Y	2	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Y	2	Abstract
Introduction					
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Y	3	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Y	4	Introduction
Methods					
Study design	4	Present key elements of study design early in the paper	Y	4-6	Methods: Data source Diagnosis related groups
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Y	4	Methods: Data source
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Y	4-5	Methods: Data source, Table 1
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA	NA	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers.	Y	4	Methods: Outcomes, Table 1

		Give diagnostic criteria, if applicable			
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Y	4-7	Methods: Data source, Outcomes, Table 1, Diagnosis-related groups
Bias	9	Describe any efforts to address potential sources of bias	NA	NA	NA
Study size	10	Explain how the study size was arrived at	Y	4	Methods: Data source
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Y	7	Methods: Analysis
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Y	7	Methods: Analysis
		(*b*) Describe any methods used to examine subgroups and interactions	NA	NA	NA
		(*c*) Explain how missing data were addressed	NA	NA	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	NA	NA	NA
		(*e*) Describe any sensitivity analyses	NA	NA	NA
Results					
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Y	4, 7	Methods: Data source; Results: Patient characteristics
		(b) Give reasons for non-participation at each stage	NA	NA	NA
		(c) Consider use of a flow diagram	Not used	Not used	Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Y	7	Results: Patient characteristics

		(b) Indicate number of participants with missing data for each variable of interest	NA	NA	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Y	4	Methods: Data source, Outcomes
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Y	7	Results
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA	NA	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	NA	NA	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Y	7	Results
		(*b*) Report category boundaries when continuous variables were categorized	NA	NA	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	NA	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	NA	NA
Discussion					
Key results	18	Summarise key results with reference to study objectives	Y	8	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Y	9	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Y	8-10	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Y	8-9	Discussion
Other information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Y	10	Funding source