

BMJ Open Autotransfusion in low-resource settings: a scoping review

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ABSTRACT

Introduction Globally, haemorrhage is the leading cause of both maternal mortality and preventable trauma death. For patients suffering from haemorrhage, prompt blood transfusion can be life-saving; however, safe and sufficient blood is often lacking in low-resource settings (LRS). Autotransfusion (AT), in which the patient's own blood is collected and transfused back, is an established alternative to donor blood transfusions, although one that is primarily performed with advanced AT systems. Research on basic AT in LRS is scarce. Therefore, we aimed to consolidate all available information on the current use of basic AT in LRS and to identify AT techniques and devices described for use in such settings.

Design Scoping review.

Methods We systematically searched four key databases: PubMed, Web of Science, Global Health and Cochrane Library as well as several grey literature databases and databases of relevant organisations. The final search was conducted on 22 April 2019. We included all types of studies referring to any information on basic AT used or sought to be used in LRS, published in English and dated after 31 December 2008. We synthesised the data from the included studies, results were charted or summarised narratively.

Results Some 370 records were reviewed, yielding 38 included documents. We found a paucity of scientific evidence as well as contradictory information on the extent of AT use and that AT use is largely undocumented. The most commonly described indications were haemoperitoneum (primarily among obstetric patients) and haemothorax. We identified three AT techniques used in LRS. Additionally, two new devices and one filter are described for potential use in LRS.

Conclusions Basic AT is practiced for certain obstetric and trauma indications. However, context-specific studies are needed to determine the technique's safety and effectiveness. Extent of use is difficult to assess, but our results indicate that basic AT is not a widely established practice in LRS. Future research should address the bottlenecks hampering basic AT availability. New AT devices for use in LRS are described, but their utility and cost-effectiveness remain to be assessed.

INTRODUCTION

Haemorrhage is the leading cause of both preventable trauma death¹ and maternal mortality worldwide.² These deaths may be prevented if haemorrhage is stopped and blood loss is compensated with blood transfusion. Blood transfusion is considered an

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We used a robust search strategy, including four electronic databases, 34 grey literature databases and the databases of three relevant organisations, to comprehensively describe the literature.
- ⇒ We included all types of literature such as journal articles, book chapters, theses, and manuals.
- ⇒ The scoping review method allowed insight into non-governmental organisation use of and interest in autotransfusion, rendering a comprehensive outline of autotransfusion in low-resource settings.
- ⇒ Our searches were restricted in terms of language and publication date.
- ⇒ This review is limited by a shortage of research.

essential part of any effective healthcare³ and saves millions of lives each year.⁴ Globally, blood transfusions have increased, but the availability of blood and safe transfusion continues to be scarce, particularly in low-income and middle-income countries (LMICs).⁵ In LMICs, an estimated 94% of the population lack access to safe, timely and affordable surgical and anaesthetic care.⁶ Improved access to surgical care and blood transfusions is key to achieving the United Nations' Sustainable Development Goal of universal health coverage for all by 2030.⁷ Resource availability varies greatly within LMICs; those living in low-resource settings (LRS) are particularly burdened. In such settings, a combination of inter-related resource constraints, such as material, financial or human resource constraints, hampers the provision of healthcare.⁸ These settings are most often found in low-income countries,⁹ but subgroups exist within all World Bank country classifications.⁸ Even when blood is available, unsafe transfusions carry significant risks of spreading blood-borne diseases such as HIV and hepatitis.⁵ Consequently, alternative strategies are desperately needed to secure the availability of safe blood in LRS.^{6 10}

Autotransfusion (AT) is an established technique that may serve as an alternative to blood transfusion using donor blood. In



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AT, the patient's shed blood is collected and reinfused into the same patient. AT has been shown to limit the need for donor blood,^{11–14} and studies have also demonstrated that the technique is effective,¹⁵ safe^{12 15} and cost-effective.^{11 13 16} In AT, there is no need for blood typing or cross-matching, and the risks of transfusion reaction to blood mismatch or transmission of blood-transmittable diseases are minimised.¹⁷ Risks associated with AT include coagulopathy, infection and sepsis.¹⁸ However, these complications remain theoretical, as studies have been unable to single out the autotransfused blood itself as the cause.¹⁸

Differences in AT systems and the indication for their use are affected by resource availability.¹⁷ In high-resource settings, advanced AT systems are used in non-urgent surgery—primarily cardiac, vascular and orthopaedic surgery. These systems are closed, meaning the blood does not come into contact with the air. Suction is used to collect blood, the blood is then washed in several steps, thus producing processed blood.¹⁷ Such advanced systems are costly, technically complex and require electrical power and trained technicians to operate.^{16 19} In LRS, basic AT has been adopted and is used in emergency surgery, such as in ruptured ectopic pregnancy (REP) surgery,¹⁷ wherein patients often present late at the hospital and access to blood is imperative. In contrast to the advanced systems used in high-resource settings, basic AT techniques are generally open, meaning the blood is at some point exposed to the air, and the collected blood is unwashed and thus unprocessed.¹⁸ AT in LRS is typically performed by assembling available material commonly found in healthcare facilities.^{17–19} The technique has been described as a life-saving measure and a last resort when no other means are available.²⁰

There is an urgent need to lower the number of deaths due to haemorrhage in LRS. However, the short supply of safe blood is a major bottleneck. Although AT has been well researched,^{11–16} and is an established procedure in high-resource settings, there is a paucity of studies addressing its use in LRS. A recent systematic review highlights the dearth of studies with a focus on blood transfusion therapies in LMICs.²¹ Therefore, all available information on basic AT, both within and outside the scientific community, must be systematically consolidated. We aimed to explore the current use (extent and indications) of basic intraoperative AT in LRS and to identify any AT devices and techniques described for use in these settings.

METHODS

We conducted a scoping review of academic and grey literature. We based the method on Arksey and O'Malley's model²² and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews.²³

Inclusion criteria

We scanned English literature published after 31 December 2008 for eligibility. We included all types of material on basic AT. We defined AT as the process of collection and reinfusion of shed blood from a human patient while on the operating table. We defined basic AT as AT techniques described for use in an LRS or an AT device designed, used or tested for use in an LRS. For records lacking information on which kind of AT device or method was used, we included records if they were reported from the healthcare systems of low-income or lower-middle-income countries.²⁴ Materials reported from upper-middle-income or high-income countries were considered if AT was aimed for use in a context indicative of an LRS. In cases of uncertainty regarding which context the AT was intended to be used for, we chose to include rather than exclude material.

Data sources and searches

Primary data sources

We conducted the primary search in the PubMed, Web of Science, Global Health, and Cochrane Library electronic databases. The search strategy for each database was developed in collaboration with a medical librarian at Karolinska Institutet. Search terms were based on the key concepts autotransfusion and low-resource setting and were further developed using synonyms of those key concepts with the help of medical subject headings, a thesaurus, and by using free word association. An iterative process was used to improve literature coverage. The last search was conducted on 22 April 2019. The full search strategy for PubMed is provided in online supplemental file 1.

Additional data sources

First, we conducted the grey literature search in the Google Scholar, Global Index Medicus, and Popline databases. Second, we searched 31 webpages from Grey Matters checklist provided by the Canadian Agency for Drugs and Technologies in Health.²⁵ Third, we searched webpages and databases of international organisations with experience in LRS: Médecins Sans Frontières (MSF), the WHO, and the International Committee of the Red Cross (ICRC). Finally, we searched six online journals considered relevant to our topic. A list of the additional data sources is provided in online supplemental file 2.

We searched each webpage, online journal, and Popline using single terms: autotransfusion, autologous transfusion, cell salvage, and blood salvage. Citation marks on search words were applied when deemed necessary. Built-in search filters were used if provided by the webpages to filter for language and year.

Study selection

After removing duplicates, the records' titles and abstracts were screened for relevance and the remaining records were then read in full. When results yielded a chapter in a book or thesis and the books or thesis were obtained in

full, all their chapters were hand-searched.^{26–28} Included records were organised using the reference handling program EndNote (Clarivate, Philadelphia, Pennsylvania, USA).

Data extraction and synthesis

To describe and compare the records, we extracted and charted the following data: title, publication year, study design or type of document, whether journal articles were peer-reviewed, and the setting or organisational setting. Subsequently, we extracted and charted the following: indication for AT use, level of emphasis on AT, and the type of device or technique used for AT.

Details could vary in the AT techniques described. To provide overview, we grouped AT techniques based on their similarity. Lastly, we extracted and charted characteristics of techniques or devices: description, size of device, maintenance needs, indication for use, whether the system is open or closed, and whether electrical power is required.

To assess the extent of AT use in LRS, we collected quantitative data when available from journal articles or books, as well as descriptive reports of the extent of use. As we became familiar with the material, we noticed some additional aspects that were often described, which we therefore noted as well: concerns with AT, safety of AT, and any expressed desire for wider availability.

Patient and public involvement

There was no involvement of patients or the public, in either the design, conduct or reporting of this scoping review.

RESULTS

Following the removal of duplicates, 370 records remained for screening. Of these, 38 were included in the

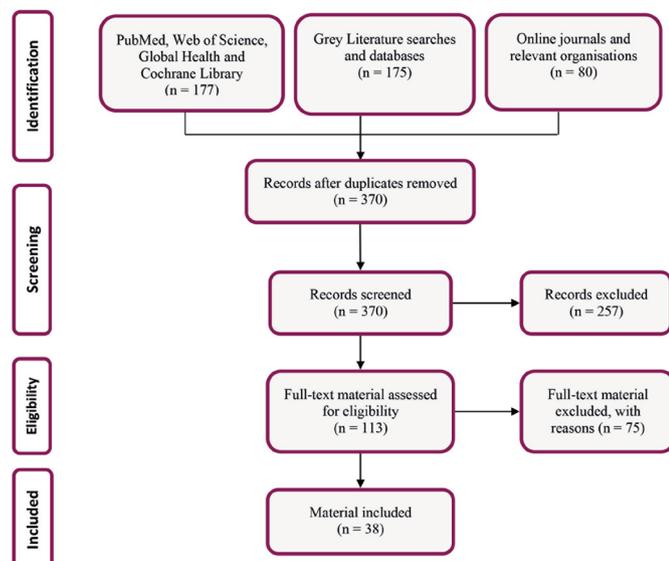


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews flowchart.

final analysis (figure 1). The full reference list and characteristics of the included records can be found in online supplemental file 3.

Outline of records included

The included records were grouped into five categories: journal articles, book chapters, theses, policy documents and blog posts (table 1).

Emphasis on AT was assessed and sorted as: main theme (8 records),^{28–35} section (6 records)^{18 36–40} or mentioned (24 records) (online supplemental file 4).

Only one journal article specifically studied the clinical use of AT in an LRS.²⁹ The remaining research articles either reported on the development of an AT device for use in an LRS^{30–34} or did not have AT as their main theme.^{36–38 41–47}

AT in LRS continues to be thought of, reported as, or portrayed as a safe^{26 28 29 41} and life-saving technique.^{18 27 35 39 48} Five sources expressed a desire for, or encouraged wider availability of, AT.^{36 42 43 49 50} Among their authors were the WHO and Malawi's Ministry of Health.

AT use in various indications

Table 2 shows the different indications for AT use in our identified records.

Haemoperitoneum

In total, 22 records (13 mention, 4 main theme) related the use of AT to ectopic pregnancy (EP), REP, ruptured uterus, intra-abdominal haemorrhage, and blood from the peritoneal cavity.

Table 3 summarises the numerical data and descriptive comments regarding AT use identified in journal articles and one book chapter. The only record that specifically studied AT in an LRS was a prospective interventional study of AT use for 212 REP patients in West Africa.²⁹ The authors reported no deaths or adverse events.²⁹ Four studies did not have AT as their main theme; however, the number of cases of AT compared with the study sample sizes in these studies show that the AT usage rate is low, whereas donor blood transfusion is more common. In three of the studies, AT was discussed but not used.^{42 43 51} Most descriptive comments state that AT is poorly used or not available. Contrarily, one study and one narrative review report a frequent usage rate of AT.^{38 51}

The WHO had authored seven of the included records (six mention, one section). Four records referred to AT in REP or EP,^{40 47 52 53} while three did not state the indication for use.^{49 50 54} In 2009, during the WHO's executive board meeting, the organisation described the importance of a wider introduction of AT and expressed an ambition to support or endorse AT as AT techniques are 'not practised on a widespread scale (in Africa)'.^{49 50 54} The WHO was involved in the planning and endorsement of the West African clinical study described above.^{29 52 53}

A book chapter describing MSF experiences in LRS stated that AT has saved many lives and that MSF teams

Table 1 Overview of included records

Record category	Number (peer-reviewed)	Details
Journal articles	16 (14)	6 primary research articles ^{29–31 41–43} 5 narrative review articles ^{32 36–38 44} 2 brief communications ^{33 45} 1 conference abstract ³⁴ 1 conference summary ⁴⁶ 1 news article ⁴⁷
Book chapters	4	1 operation preparations for orthopaedics in LRS ²⁶ 1 management and outcome of ectopic pregnancy in LRS ⁵¹ 1 MSF experience of anaesthesia in LRS ²⁷ 1 obstetric and gynaecological surgery and blood supply in LRS ³⁹
Theses	3	1 master's theses ^{63 57} 1 PhD thesis chapter ²⁸
Policy documents	10	3 WHO ^{49 50 54} 2 WHO (in collaboration with UN) ^{52 53} 1 WHO, UN and UNICEF ⁴⁰ 1 MSF ⁵⁸ 1 ICRC ¹⁸ 1 Malawi Ministry of Health ⁶⁴ 1 Bangladesh Ministry of Health ⁶⁵
Blogs posts	5	3 MSF—Sierra Leone ^{48 55 66} 1 MSF—Pakistan ⁵⁶ 1 MSF—Central African Republic ³⁵

ICRC, International Committee of the Red Cross; LRS, low-resource settings; MSF, Médecins Sans Frontières; UN, United Nations; UNICEF, United Nations International Children's Emergency Fund.

who are experienced with the technique often use it.²⁷ MSF blog posts from Sierra Leone, Pakistan, and the Central African Republic conveyed a sense of routine use of AT.^{35 55 56} However, education on how to perform AT was done *ad hoc* and not prior to mission dispatch.^{35 48}

Table 2 Indications for autotransfusion use

Indication as described by record	Number of records
Ruptured ectopic pregnancy (REP)	12
Ectopic pregnancy	4
Haemothorax	5
Vaginal postpartum haemorrhage	3
Abdominal trauma and REP	1
Haemothorax and REP	1
Haemothorax and intra-abdominal haemorrhage	1
Blood from the peritoneal cavity	1
Maternal haemorrhage	1
Ruptured uterus	1
Thyroid surgery	1
Several indications	2
Not specified	5

Haemothorax

We did not identify any scientific studies on AT use in haemothorax. Moreover, AT in haemothorax was generally only mentioned (seven mention, one section). Two journal articles summarise the African Federation for Emergency Medicine Consensus Conference in 2013, where supplies for AT from chest tubes were deemed necessary equipment for an advanced emergency care service.^{44 46} Six grey literature records addressed AT use in haemothorax.^{18 26 27 44 46 56–58} Two chapters from books on orthopaedic and anaesthetic care in LRS, respectively, mentioned AT in haemothorax. In the first chapter, AT was mentioned as a possible life-saving option and reported to be used in extreme acute cases.²⁶ The second mentioned AT as a necessary technique when blood supply is limited and stated that experienced MSF teams often perform the procedure.²⁷ A 634-page manual by the ICRC for surgeons working with limited resources devoted a whole chapter to AT and mentioned the technique several times throughout the manual in regards to haemothorax.¹⁸ AT in haemothorax was described as frequently used for patients with war wounds in Afghanistan in 1981–1984. The extent of use was not otherwise specifically addressed; however, usage was encouraged, and AT use and techniques in several indications were described in detail. A master's thesis included a descriptive cross-sectional study of emergency care in Zambia in which none of the 23 assessed healthcare facilities were able to perform AT from chest tubes due to lack of training and supplies.⁵⁷ One MSF blog described a

Table 3 The use of autotransfusion in ectopic pregnancy (EP)

Title, including setting, and record category	Study design/article type	Study sample and indication	Number of AT cases	Donor blood units received (median units received)	Descriptive comment from the articles on the use of AT
Multicentre experience with a simple blood salvage technique in patients with ruptured ectopic pregnancy in sub-Saharan West Africa, ²⁹ journal article	Prospective interventional study	212 REP	212	22 (1)	N/A
A five year review of ectopic pregnancy at Federal Medical Centre, Owerri, south east Nigeria, ⁴² journal article	Retrospective review	382 EP	0	248 (1)	AT in some tertiary centres was underused or not used at all. AT should be encouraged and considered as primary choice in the management of tubal pregnancy with haemoperitoneum.
The impact of tubal ectopic pregnancy in Papua New Guinea – a retrospective case review – provincial referral hospital, ⁴³ journal article	Retrospective review	73 tubal EP	0	49 (2)	AT was not available at the hospital.
Comparative analysis of morbidity and mortality due to ectopic pregnancy at a tertiary care hospital in Nigeria over two study periods, ⁴⁵ journal article	Retrospective review	367 EP	54	234 (N/A)	AT has an important role in EP management in settings where transfusion services are not optimal.
Management and outcome of ectopic pregnancy in developing countries, Nigeria, ⁵¹ book chapter	Prospective cohort study	1 EP, 12 REP	0	N/A* (0)	AT is done in most rural centres.
Blood transfusion safety; current status and challenges in Nigeria, ³⁶ journal article	Narrative review	N/A	N/A	N/A	Poor utilization and practice of AT. AT needs to be encouraged.
The use of blood in obstetrics and gynecology in the developing world, ³⁸ journal article	Narrative review	N/A	N/A	N/A	There is a long history and frequent use of AT in areas with minimal resources.

*It was stated that the 12 patients presenting with REP received whole blood from other individuals, as blood products were not available at the centre. Whole blood was not further defined in the book.
AT, autotransfusion; N/A, not available; REP, ruptured ectopic pregnancy.

case of AT use in a patient with haemothorax caused by a gunshot injury.⁵⁶

Other indications

In a retrospective study of the experience gained from a mobile surgical mission in rural areas in southern Sudan, AT was mentioned in regards to elective thyroid surgery.⁴¹ However, the technique or device that was used was not stated. The ICRC war surgery manual mentions the utility of AT in cases of limb fracture, ruptured spleen and substantial blood loss during surgery.¹⁸

AT techniques, devices and filter for LRS

Twenty-six records described or mentioned one or more AT techniques or devices. We identified three different techniques described for clinical use: the soup-ladle

technique, the chest-bottle inversion technique, and the Tanguieta funnel. Two devices (Hemafuse and the post-partum haemorrhage (PPH) AT device) and one filter (leucocyte depletion filter) were described as possible alternatives for use in LRS. Features of the techniques, devices, and filter are presented in [table 4](#).

Soup-ladle technique

The soup-ladle technique is described for use in haemoperitoneum. Variations were identified for each step.

Collection

Collecting blood was done with a soup ladle, bowl, cup, gallipot, kidney dish or with laparotomy suction, sump aspiration or using syringes—either through the

**Table 4** Techniques, devices, and filter identified for autotransfusion (AT)

Name (number of records that mention the technique/device/filter)	Description	Indication for use	Electrical power	Open or closed system	Filter	Maintenance	Size
Techniques in use							
Soup-ladle technique (14)	Shed blood is scooped from abdomen using a soup ladle. Blood is filtered through gauze, added to anticoagulant and reinfused via transfusion kit.	REP	None	Open	Layers of gauze	Ladle and collection object may be autoclavable. Tubing and transfusion sets are disposable.	N/A
Chest-bottle inversion technique (6)	Sterile chest bottle/glass jar containing 100 mL of normal saline collects the blood and is then disconnected and inverted to become the administration set.	Haemothorax	None	Closed or open	Preferably through layers of gauze before collection in bottle, then through 'standard transfusion set'	Glass jars are autoclavable. Tubing and transfusion sets are disposable.	N/A
Tanguieta funnel (7)	Funnel of surgical steel with perforations removing clots >1 mm. Two large syringes, two clamps for tubing, prefilled 450 mL blood bags with 63 mL CPDA solution. Funnel lowered into pools of blood. Blood aspirated with syringes connected to tubing of blood bag. Transfused back via blood bag with a filter.	REP	None	Open	200 µm filter	N/A	High 24 cm, diameter 6.7 cm
Devices and filter not yet in use							
Hemafuse (2)	Resembling an oversize syringe, blood is sucked in through nozzle and filter, pooling blood into barrel. Pushing back on plunger leads blood via one-way valve into standard blood bag. Clots accumulate in nozzle.	REP	Mechanical	Closed	170 µm filter	Disposable filter, the rest autoclavable.	33×11×7.5 cm
PPH AT device (3)	Collection drape placed under buttock funnels blood into a circuit, pumped through filter to a reservoir standard transfusion bag. Vinyl tubing between. Retransfused via intravenous line. Meshing within the drape removes large clots.	PPH	Peristaltic blood pump with 12 V, 400 mA DC motor	Open	3 Pall LeukoGuard filters arranged one after the other	Disposable drape and tubes. Pump is reusable and not in contact with blood; sterilisation therefore not needed.	N/A
Leucocyte depletion filter (1)	Leucocyte depletion filter alone without centrifuge and cell washing process. No further information provided on collection, reservoir or reinfusion.	Maternal haemorrhage	None	Open	The leucocyte filter itself	Disposable	N/A

CPDA, citrate-phosphate-dextrose-adenine anticoagulant; DC, direct current; N/A, not available; PPH, postpartum haemorrhage; REP, ruptured ectopic pregnancy.

abdomen wall prior to opening the abdomen or after opening the abdomen.

Filtering

Blood was primarily filtered through gauze. Two records specified the number of layers of gauze (5–8 and 6–8 layers). One MSF blog post mentioned filtering with the use of cheesecloth, while two MSF blog posts did not specify what was used to filter the blood.

Adding anticoagulant

Sodium citrate, citrate-phosphate-dextrose-adenine (CPDA) solution, heparin, or ‘anticoagulant’ (not further specified) was added to the blood either before or after filtering. Three records were more specific: half of a normal dose CPDA or 500–1000 units of heparin per unit blood,¹⁸ 10 mL of sodium citrate added to 90 mL of blood,⁴⁰ or 60 mL of 3.8% sodium citrate.³⁷ MSF blog posts did not discuss the use of anticoagulant.

Reinfusion

Reinfusion was used with a transfusion kit, donor bag, sterile bottle, blood bag, intravenous bag or a glass bottle with a rubber top.

Two records provided instructions on how to perform AT in EP: the ICRC manual and a guideline for midwives and doctors published by the WHO, United Nations and United Nations International Children’s Emergency Fund (UNICEF).^{18 40} In the latter, shed blood was not to be used ‘in the later stages of pregnancy’.⁴⁰ Only one additional record, the West African study, cited a limit for the use of shed blood for AT: if the woman was more than 3 months pregnant.²⁹

Chest-bottle inversion technique

The chest-bottle inversion technique is described for use in haemothorax. In this technique, blood is collected from the chest cavity via chest tubes. Two records, the ICRC manual¹⁸ and an MSF manual for doctors, nurses, and laboratory technicians working in resource-limited health facilities,^{18 58} described the technique in detail. MSF promoted blood collection into a blood bag by inserting a needle into a Heimlich valve, followed by immediate retransfusion. The ICRC described blood from the chest tubes being filtered through gauze and collected into a chest bottle with 100 mL saline solution, followed by its inversion into an infusion set. The ICRC also suggested that blood could be collected directly into a standard transfusion set (similar to MSF) or into a urine bag without saline. In haemothorax, anticoagulant is preferably not used as the blood is already defibrinogenated by the movement of the lungs.¹⁸ The use of shed blood for AT was limited to 6 and 2 hours by the ICRC and MSF, respectively.

Tanguieta funnel

The Tanguieta funnel is described for use in patients with REP. The technique involves a cone-shaped steel funnel with 1 mm holes punctured in the lower two-thirds

being lowered into pools of blood immediately removing blood clots larger than 1 mm. Blood within the funnel is then collected with syringes and transferred to blood bags. The Tanguieta funnel was the only AT technique for which we were able to identify a clinical scientific study. In a prospective interventional study carried out in three hospitals in Benin and Burkina Faso, 212 patients with REP were treated using the funnel.²⁹ No deaths or adverse effects associated with AT were observed. The authors concluded that postoperative infection rates were comparable to those of previous reports of EP from Niger and Senegal.

Hemafuse

The Hemafuse is a hand-held mechanical device developed and designed for AT in patients with REP in LRS.³³ The device is shaped like an oversized syringe. Shed blood is collected via suction, passed through built-in filters and then pushed out via an outlet valve to a standard blood bag. According to the authors of a brief communications journal article, the Hemafuse is less labour intensive and requires fewer disposables than the soup-ladle technique and the Tanguieta funnel.³³ The article briefly described preclinical trials where simulated blood was used to confirm processing rates, and tests of reconstituted human blood indicated that the device had no negative effect on haematocrit and plasma haemoglobin levels.³³ Conflict of interest was reported, as five of the authors had filed a patent for the device.³³

PPH AT device

The PPH AT device was designed to salvage blood for AT in LRS from vaginal delivery. The technique includes placing a collection drape under the buttock and pooling the blood toward a device where blood is pumped through filters and collected in a standard transfusion bag. The developers present the development process and technical aspects of the device in three journal articles.^{30 32 34} These articles described how bacterial reduction was tested with two types of filters and several configurations of the filters on heparinised porcine blood to optimise filter function. Preliminary testing demonstrated that up to 97% of the bacterial load was reduced.^{30 32} However, filtration of amniotic fluid markers was not tested. Conflict of interest was reported, as two of the authors had filed a patent for the device.³²

Leukocyte depletion filter

The leukocyte depletion filter is typically used together with advanced centrifugation and cell washing devices.³¹ One study explored the possibility of using the filter alone to remove amniotic particulates and molecular components from blood salvaged from caesarean sections.³¹ The authors of the journal article found that the filter was efficient for the removal of lamellar bodies, foetal squames and hair, but that it could not remove α -fetoprotein, tissue factor or endothelin-1 concentrations, meconium



or vernix. The authors concluded that in cases where no alternative exists, the filter alone may prove useful.

DISCUSSION

This scoping review identified only one clinical study of AT in LRS,²⁹ highlighting the dearth of context-specific research in this area. In addition, experience with the technique and the extent of AT use are poorly described in both peer-reviewed and grey literature. The included journal articles were mainly narrative reviews or focused on the development of new commercial AT devices for use in LRS. The utility of these devices remains to be assessed.

We derived three main research gaps. First, our findings indicate that knowledge of AT in LRS exists, but that the use of the technique remains largely undocumented. Large non-governmental organisations (NGOs) provide protocols on how to perform the technique.^{40 58} In addition to these protocols, the WHO's interest in the Tanguieta funnel, as well as the African Federation for Emergency Medicine's decision to regard supplies for AT in haemothorax as essential, clearly demonstrate that AT is known and is considered advantageous. However, our results also suggest that common knowledge and know-how of AT in LRS is largely absent. For example, in Zambia, AT in haemothorax was not practiced due to lack of training and shortage of supplies.⁵⁷ MSF blog posts indicated that basic AT was learnt *ad hoc*.^{35 48} These examples may be key reasons for limited usage and are in agreement with a recent interview study by Sjöholm *et al* on the use of basic AT within NGOs.²⁰ In that study, insufficient knowledge and experience with basic AT, as well as insufficient dissemination of protocols, were outlined as the main bottlenecks to wider usage of the technique. The underdocumentation of emergency indications is a critical barrier to wider availability of emergency care.⁴⁶ The emergency situation itself poses challenges to appropriate data collection and research,⁵⁹ and in contrast to AT use in high-resource settings, AT in LRS is a treatment used in emergency situations. Our findings suggest that focus should be directed at improved data collection to facilitate better understanding of the extent of AT use in LRS. Ultimately, we have shown that the extent of knowledge on and use of AT is not assessable, as the quantitative data and descriptive reports are meagre and contradictory.

Second, although basic AT is used and advocated as an important life-saving procedure in LRS, the safety and effectiveness of the technique and its different variations remain to be assessed. This point was emphasised in one thesis included in our study.²⁸ Large institutions (African Federation for Emergency Medicine, the WHO and Malawi's Ministry of Health) promote wider availability of AT. The WHO states that AT has 'undisputed advantages in regard to safety'.⁵⁴ However, it is unclear whether that knowledge of AT is based on research from high-resource settings or on experiences from LRS. Although the

included record by Priuli *et al*²⁹ demonstrated no adverse outcomes connected to the use of the Tanguieta funnel in 212 cases of REP, we were unable to validate basic AT as a safe procedure. These findings are in line with the 2003 review by Selo-Ojeme *et al*, which claims that although the safety of basic AT in REP is not established, desperate circumstances justify its use.¹⁷ Evidence to support contra-indications such as infection, sepsis and embolism are said to be few, and these concerns are claimed to be theoretical.^{18 38}

Finally, new low-tech devices aimed at LRS may soon be available, but their utility, safety, effectiveness, and cost-effectiveness remain to be studied. In contrast to an advanced AT system, which can be used across several indications, the newer systems outlined in this article are aimed at specific indications. A low-tech device suitable for LRS should be simple, safe, inexpensive, not dependent on a power grid, and demand minimal human resources.¹⁸ The soup-ladle technique has been perceived as a technically challenging technique.^{18 29 35} In a journal article, the WHO went as far as describing the technique as a crude measure that reflects global health authorities' failure to provide adequate healthcare for LMICs.⁴⁷ The Tanguieta funnel, the Hemafuse, and the PPH AT device are all claimed to be simple or intuitive. Such characteristics would involve less training, minimise human resource dependency and circumvent some of the bottlenecks pointed out by Sjöholm *et al*.²⁰ The PPH AT device was the only identified device that requires electrical power. In LRS, such requirements tend to limit the utility outside of health facilities. The high rate of PPH mortality in LRS can in part be explained by the high proportion of home births.⁶⁰ Consequently, AT devices and know-how at a health facility may not reach and benefit women in their homes. As much as 70% of donated medical devices from high-resource settings have been left unused in LRS because they do not suit the environment.⁶¹ The utility of AT devices must be evaluated in context-specific studies. Likewise, research comparing newer devices to existing techniques should be performed in LRS. Additionally, cost is of particular interest. One can assume that the cost for patented devices (eg, the Hemafuse and the PPH AT device) is greater than that of assembling already present and common material in the hospital.

There are several limitations to this scoping review. First, by including variations of 'LRS' in our search strategy, AT techniques used in high-resource settings relevant for use in LRS might have been missed. Second, our searches were restricted to records published in English and dated later than 2008. Consequently, older relevant studies may have been missed, as well as non-English insight, for example, from parts of Africa or the South American continent where French or Spanish are spoken. To compensate for these search restrictions, our grey literature search was conducted in a large number of databases and we believe that our review provides a comprehensive mapping of the body of knowledge of AT use in LRS. Third, the screening process for record inclusion was

conducted by only one reviewer, which may have led to the introduction of selection bias. To minimise this risk, we chose a liberal approach, tending to include rather than exclude material. Finally, although the method of a scoping review accommodates all types of literature, it does not assess the quality of included records.²² Compared with scientific records, non-scientific records are presumably more likely to report positive results than adverse outcomes. The associated risk of publication bias emphasises the need for research on AT in LRS. However, we aimed to transparently describe where information was derived to give the reader a chance to assess the credibility of the data. The scoping review method allowed a broad assessment of basic AT use in LRS. Had a systematic review been performed instead, 22 of the included documents would have been excluded. Consequently, NGO use of and interest in AT would have been overlooked.

Globally, the leading cause of maternal death and preventable trauma death is haemorrhage. Together with the provision of safe and sufficient blood supply, access to essential health technologies, including medical devices, is a cornerstone of universal healthcare coverage.⁶² Basic AT is considered a life-saving technique in LRS and its wider use is encouraged, suggesting that AT in LRS may not have reached its full potential. However, the underdocumentation and contradicting reports on its use, differences in contraindications, and variations on how to perform the technique—as revealed in our results—indicate that basic AT is neither a standardised nor an established practice in LRS. In light of the scant body of evidence, continuous promotion of the technique is concerning. Likewise, introducing advanced AT devices to LRS has been deemed inappropriate.²⁹ Since the WHO began publishing the annual *Compendium of Innovative Health Technologies for Low-Resource Settings* in 2010, the report has not yet featured an AT device. Our study provides a collected platform of knowledge of basic AT use, available techniques and devices.

CONCLUSIONS

AT is practiced in LRS for certain obstetric and trauma indications, but the extent of its use is difficult to assess. Our findings suggest that knowledge and use of the technique are not widely established in the medical community of LRS. New low-tech AT devices are being developed, but evaluations of these devices' safety, effectiveness and cost-effectiveness are needed. Our results may prove useful to inform the planning of future studies that aim to address the evidence deficit regarding basic AT use in LRS.

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Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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SUPPLEMENTARY FILES

Supplementary File 1: Search strategy

PubMed

Blood Transfusion, Autologous [Mh] OR Autologous Blood Transfusion [tiab] OR Autotransfusion [tiab] OR Autotransfusions [tiab] OR Autologous Blood Transfusions [tiab] OR Operative blood salvage [Mh] OR Intraoperative Blood Salvage [tiab] OR Postoperative Blood Salvage [tiab] OR Post-Operative Blood Salvage [tiab] OR Post Operative Blood Salvage [tiab] OR Intraoperative Blood Cell Salvage [tiab] OR cell salvage [tiab] OR blood salvage [tiab] OR perioperative blood salvage [tiab] OR peri-operative blood salvage [tiab] OR "auto transfusion"[tiab] OR "auto-transfusion"[tiab]

AND

developing countries [Mh] OR developing world [tiab] OR Developing Country [tiab] OR Least Developed Countries [tiab] OR Least Developed Country [tiab] OR Less Developed Countries [tiab] OR Under-Developed Nations [tiab] OR Under Developed Nations [tiab] OR Under-Developed Nation [tiab] OR Third-World Countries [tiab] OR Third World Countries [tiab] OR Third-World Country [tiab] OR Third-World Nations [tiab] OR Third World Nations [tiab] OR Third-World Nation [tiab] OR Under-Developed Countries [tiab] OR Under Developed Countries [tiab] OR Under-Developed Country [tiab] OR Developing Nations [tiab] OR Developing Nation [tiab] OR Less-Developed Nations [tiab] OR Less Developed Nations [tiab] OR Less-Developed Nation [tiab] OR Health care Rationing [Mh] OR Healthcare Rationing [tiab] OR Cost savings [Mh] OR Cost Saving [tiab] OR Disaster Medicine [Mh] OR Disaster setting [tiab] OR Catastrophe medicine [tiab] OR Catastrophe setting [tiab] OR Catastrophe settings [tiab] OR LIC [tiab] OR LMIC [tiab] OR low income country [tiab] OR low income countries [tiab] OR low-income country [tiab] OR low-income countries [tiab] OR low income economy [tiab] OR low income economies [tiab] OR low-income economy [tiab] OR low-income economies [tiab] OR low income nation [tiab] OR low income nations [tiab] OR low-income nation [tiab] OR low-income nations [tiab] OR low middle income country [tiab] OR low middle income countries [tiab] OR low-middle income country [tiab] OR low-middle income countries [tiab] OR low middle income economy [tiab] OR low middle income economies [tiab] OR low-middle income economy [tiab] OR low-middle income economies [tiab] OR low middle income nation [tiab] OR low middle income nations [tiab] OR low-middle income nation [tiab] OR low-middle income nations [tiab] OR limited resource [tiab] OR limited resources [tiab] OR resource limitation [tiab] OR resource limit [tiab] OR field hospital [tiab] OR field hospitals [tiab] OR emerging market [tiab] OR

emerging markets [tiab] OR emerging country [tiab] OR emerging countries [tiab] OR emerging nation [tiab] OR emerging nations [tiab] OR emerging economy [tiab] OR emerging economies [tiab] OR trauma [tiab] OR resource poor [tiab] OR resource-poor [tiab] OR remote setting [tiab] OR remote settings [tiab] OR remote environment [tiab] OR remote environments [tiab] OR resource scarce [tiab] OR scarce resource [tiab] OR scarce resources [tiab] OR austere environment [tiab] OR austere environments [tiab] OR austere setting [tiab] OR austere settings [tiab] OR low-resource setting [tiab] OR low-resource settings [tiab] OR low resource setting [tiab] OR low resource settings [tiab]

Mh, medical subject heading term; tiab, title/abstract

Supplementary File 2: Additional data sources

<i>Sources of grey literature searches</i>	Global Index Medicus
	Google Scholar
	Popline
<i>Grey literature sources indexed in Grey Matters checklist provided by The Canadian Agency for Drugs and Technologies in Health</i>	Queensland Government. Health Technology Reference Group – Council of Australian Governments
	The Alberta College of Family Physicians
	Canadian Agency for Drugs and Technology in Health
	Health Quality Council of Alberta
	Health Quality Ontario
	Institut national d'excellence en santé et en services sociaux
	Institute of Health Economics
	McGill University Health Centre
	Newfoundland Labrador Centre for Applied Health Research. Contextualized Health Research Synthesis Program
	Programs for Assessment of Technology in Health
	International Network of Agencies for Health Technology Assessment Secretariat
	World Health Organization Regional Office for Europe. Health Evidence Network
	Joanna Briggs Institute
	Institute of Technology Assessment
	Ludwig Boltzmann Institut
Belgian Health Care Knowledge Center	
Sundhedsstyrelsen. Danish Health and Medicines Authority	
Comité d'Evaluation de Diffusion des Innovation Technologiques	
Health Information and Quality Authority	

	Health Service Executive
	Sahlgrenska Universitetssjukhuset
	National Institute for Health and Care Excellence
	National Institute for Health Research. Innovation Observatory
	National Institute for Health Research Evaluation, Trials and Studies Coordinating Centre
	Alberta Health and Wellness
	Manitoba Centre for Health Policy
	Haute Autorité de santé /French National Authority for Health
	Zorginstituut Nederland. National Health Care Institute Netherlands
	Agencia de Evaluación de Tecnologías Sanitarias, Instituto de Salud "Carlos III"
	Agency for Healthcare Research and Quality
	Centers for Medicare & Medicaid Services
<i>Supplemented sources of grey literature</i>	International Development Innovation Network
	Center for Health Market Innovation
	Medbox the Aid Library
	International Federation of the Red Cross
	The International Disaster Database
	Canadian Best Practices Portal
<i>Webpages or databases of MSF, WHO, and ICRC</i>	msf.org
	msf.org/patent-opposition-database
	fieldresearch.msf.org/discover, blogs.msf.org/search
	apps.who.int/iris/
	kohahq.searo.who.int
	icrc.org
<i>Online journals</i>	Transfusion Alternatives in Transfusion Medicine
	Transfusion and Apheresis Science
	Emergency Medicine Journal
	Journal of Medical Engineering & Technology
	Transfusion Medicine
	Disaster and Military Medicine

MSF, Médecins Sans Frontières; WHO, World Health Organization; ICRC, International Committee of the Red Cross

Supplementary File 3: Characteristics of records included

Title, year of publication	Study design/type of document/further details (peer reviewed journal)	Indication for autotransfusion	Setting/organizational setting	Emphasis on AT	Device or technique(s), described or stated
<i>Journal articles (n= 16)</i>					
Primary surgery in rural areas of southern Sudan, ²⁹ 2012	Retrospective analysis (yes)	Thyroid surgery	Southern Sudan	Mention	No
A Five Year Review Of Ectopic Pregnancy At Federal Medical Centre, Owerri, South East, Nigeria, ³⁰ 2014	Retrospective review (no)	REP	Nigeria	Mention	No
The impact of tubal ectopic pregnancy in Papua New Guinea - a retrospective case review, ³¹ 2013	Retrospective case review (yes)	EP	Papua New Guinea	Mention	No
Comparative analysis of morbidity and mortality due to ectopic pregnancy at a tertiary care hospital in Nigeria over two study periods, ⁴¹ 2015	Retrospective review. Brief communications (yes)	EP	Nigeria	Mention	No
Multicentre experience with a simple blood salvage technique in patients with ruptured ectopic pregnancy in sub-Saharan West Africa, ³² 2009	Prospective interventional study, testing of Tanquieta funnel (yes)	REP	Benin and Burkina Faso	Main theme	Tanguieta funnel
A novel obstetric medical device designed for autotransfusion of blood in life threatening postpartum haemorrhage, ³³ 2017	Development of AT-device (yes)	PPH	Low-resource setting	Main theme	PPH autotransfusion device
An evaluation of the ability of leucocyte depletion filters to remove components of amniotic fluid*, ³⁴ 2012	Test/development of cheaper solution for AT. (yes)	Maternal hemorrhage	Developing world	Main theme	Leukocyte depletion filter
In Pursuit of Solving a Global Health Problem: Prototype Medical Device for Autotransfusing Life-Threatening Postpartum Hemorrhage in Resource-Limited Settings, ³⁵ 2017	Narrative review with focus on PPH autotransfusion device (yes)	PPH	Resource-limited settings	Main theme	PPH autotransfusion device
Blood salvage device for use during ruptured ectopic pregnancy in low-resource countries, ⁴⁰ 2015	Brief communications (yes)	REP	Low-resource countries	Main theme	Soup ladle, Tanguieta funnel, Hemafuse
Blood transfusion safety; current status and challenges in Nigeria, ³⁶ 2017	Narrative review and national transfusion assessment (yes)	Abdominal trauma, REP	Nigeria	Section	No

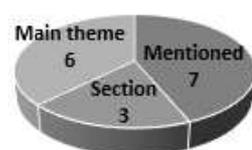
Alternatives to Blood Transfusion in Resource Limited Settings, ³⁷ 2014	Narrative review (no)	Several*	Resource limited settings	Section	Soup ladle, manual suction collection system
The use of blood in obstetrics and gynecology in the developing world, ³⁸ 2011	Narrative review (yes)	REP	Developing world	Section	Soup ladle, Tanguieta funnel
Operationalising emergency care delivery in sub-Saharan Africa: consensus-based recommendations for healthcare facilities, ³⁹ 2016	Narrative review (yes)	Hemothorax	Sub-Saharan Africa	Mention	Chest-bottle inversion technique
Emerging economies drive frugal innovation, ⁴⁴ 2013	News article (yes)	REP	WHO	Mention	Soup ladle
AFEM consensus conference 2013 summary: Emergency care in Africa—Where are we now? ⁴³ 2014	Conference summary (yes)	Hemothorax	Africa	Mention	Chest-bottle inversion technique
Testing of the filter function of a prototype device to eliminate fetal surrogate markers and bacterial load for autotransfusion in postpartum haemorrhage in low-resource settings, ⁴² 2016	Conference abstract (yes)	PPH	Low-resource setting	Main theme	PPH autotransfusion device
<i>Book chapters (n=4)</i>					
What? No Lab? Preparing the Patient for Operation, ²⁶ 2016	Book title: Orthopedic Trauma in the Austere Environment	Hemothorax, intra-abdominal hemorrhage	Austere environment	Mention	No
Management and outcome of ectopic pregnancy in developing countries, ⁴⁵ 2011	Book title: Ectopic Pregnancy-Modern Diagnosis and Management	REP	Nigeria	Mention	Soup ladle
Anesthesia in Resource-Poor Settings: The Médecins Sans Frontières Experience, ²⁷ 2015	Book title: The Role of Anesthesiology in Global Health	Hemothorax, EP	MSF	Mention	No
Ob-Gyn Surgery and Blood Supply in Resource-Poor Areas, ⁴⁶ 2016	Book title: Obstetrics and Gynecology in Low-Resource Settings	Blood from peritoneal cavity (such as REP or ruptured hemorrhagic cyst)	Resource-poor areas	Section	Soup ladle, Tanguieta funnel
<i>Theses (n=3)</i>					

Participatory design methods for medical device innovation in Uganda, ⁴⁷ 2018	Master thesis of applied science, University of British Columbia	REP	Uganda	Mention	Hemafuse
Interventions to reduce maternal mortality in developing countries: a systematic synthesis of evidence, ²⁸ 2014	Thesis for degree of doctor of philosophy, University of Birmingham	EP	Developing countries	Main theme	Soup ladle, Tanguieta funnel
Facility-based capacity assessment of emergency care services in public hospitals in Zambia, ⁴⁸ 2017	Master thesis in emergency medicine, University of Cape Town.	Hemothorax	Zambia	Mention	Chest-bottle inversion technique
<i>Documents from non-governmental organisations (n=8)</i>					
War Surgery Working with limited resources in armed conflict and other situations of violence volume 2, ¹⁸ 2013	"point of reference for health professionals engaged in providing lifesaving services in often hazardous environments"	Several*	ICRC	Section	Chest-bottle inversion technique
Annual Technical Report, 2011 ⁵² , 2012	Annual report on human reproduction	REP	WHO	Mention	Tanguieta funnel
HRP Biennial Technical report 2009-2010, ⁵³ 2011	Annual report on human reproduction	REP	WHO	Mention	Tanguieta funnel
Executive Board 125th Session, Geneva, 23 May 2009: resolution and decisions, summary records, ⁴⁹ 2009	WHO Executive Board Resolutions and Decisions summary records	Not specified	WHO	Mention	No
Second report of Committee B	Documentation from the sixty-third World Health Assembly	Not specified	WHO	Mention	No
Managing Complications in Pregnancy and Childbirth: a guide for midwives and doctors – 2 nd edition, ⁵⁴ 2017	Guide for midwives or doctors	EP	WHO	Section	Soup ladle
Compendium of public health strategies: volume 1 adopted by WHO Regional Committee for Africa (1998 - 2011), ⁵¹ 2012	Public Health Strategies Compendium	Not specified	WHO	Mention	No
Blood Transfusion - A manual for doctors, nurses and	Manual	Hemothorax	MSF	Mention	Chest-bottle inversion

laboratory technicians, ⁵⁵ 2010					technique
<i>Documents from ministry of health (n=2)</i>					
Registration Guidelines for Medical Devices Bangladesh, ⁵⁷ 2015	Medical device registration guideline for Bangladesh	Not specified	Bangladesh	Mention	No
Guidelines for Safe Blood Transfusion, ⁵⁶ 2012	Guideline	Not specified	Malawi	Mention	No
<i>Blog posts (n=5)</i>					
A first time for everything: Learning fast in Bangui, ⁶² 2018	MSF blog	REP	Central African Republic	Main theme	Soup ladle
Poetry, ⁶¹ 2014	MSF blog	Hemothorax	Pakistan	Mention	Chest-bottle inversion technique
A night to remember, ⁵⁸ 2013	MSF blog	REP	Sierra Leone	Mention	Soup ladle
Roughin' it, ⁵⁹ 2013	MSF blog	REP	Sierra Leone	Mention	Soup ladle
When it rains, ⁶⁰ 2013	MSF blog	Ruptured uterus	Sierra Leone	Mention	Soup ladle
* “useful in patients undergoing <i>elective</i> cardiothoracic surgery, selected orthopaedic surgery, and emergency/trauma surgery such as: ruptured spleen/liver, vascular injuries, urologic surgery”					
** massive hemorrhage in thorax or abdomen (hemothorax, REP, ruptured spleen, packed liver), substantial blood loss during operation (laparotomy), shed blood from limbs (fractures)					

Supplementary File 4: Level of emphasis on autotransfusion in the included records

Journal articles n=16



Other n=22

