ACORN AUSTRALIAN COLLEGE OF PERIOPERATIVE NURSES | JOURNAL OF PERIOPERATIVE NURSING

Volume 36 | Issue 3 Article 3

9-4-2023

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Recommended Citation

Hilario, Irene and Foran, Paula (2023) "Liquid gold: A discussion of the significance of using intra-operative cell salvage in hip and knee arthroplasty," *Journal of Perioperative Nursing*: Vol. 36 : Iss. 3 , Article 3.
Available at: https://doi.org/10.26550/2209-1092.1280

https://www.journal.acorn.org.au/jpn/vol36/iss3/3

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Abstract

Blood management is a vital component of a patient's journey in the perioperative environment. There is a call to incorporate intra-operative cell salvage (ICS) into blood management protocols across hospitals in Australia where invasive and major surgeries have the potential to result in massive blood loss.

Donated blood (allogeneic blood), despite its highly valued use in major blood loss events, poses risks and potential complications making cell salvage an attractive viable option in hip and knee arthroplasty. ICS is the process of returning the patient's own blood (autologous blood) back into its systemic circulation. Autologous blood is collected from blood lost by the patient during surgery and has proven to have fewer complications and more benefits when compared to donated blood. Currently, ICS is still not widely used in many hospitals in Australia and its associated costs continue to be a deterrent to hospitals integrating it into their blood management services. Despite this, many studies have proven that ICS may not just be superior to donated blood in many ways, it may also prove to be cost-efficient when one looks at the compounding results of better patient outcomes.

Keywords: intra-operative cell salvage, total knee replacement, total hip replacement, patient blood management

Introduction

Homologous or allogeneic blood (donated blood) is a vital and invaluable commodity that may sometimes be inaccessible due to its limited availability.[1–3] It is known from scholarly literature that allogeneic blood, despite its benefits, can transmit viral illness, produce haemolysis and transfusion reactions and cause periprosthetic joint infection in arthroplasties.[4,5] Some religions such as the Jehovah's Witness faith decline to accept donated blood products which has created limitations in blood use for these patients.[3,6,7] The National Blood Authority (NBA) has provided a set of guidelines for the provision of intra-operative cell salvage (ICS) that they based on the United Kingdom's policy which local clinicians have assessed to ascertain its applicability to the Australian setting.[8] Moreover, the ICS guidance has been modified and aligned with the Blood Management Standard, one of the National Safety and Quality Health Service (NSQHS) Standards published by the Australian Commission on Safety and Quality in Health Care (ACSQHC).[1] Currently, the ICS recommendation is not mandated as part of standard patient improvement measures but grants physicians and surgeons the freedom to determine which patients fit the criteria of needing cell salvage.[8]

Discussion

This discussion paper will present the importance of ICS in the perioperative environment, its advantages and disadvantages, and its clinical application not only in the primary but also in revision hip and knee arthroplasty. Scholarly literature was accessed and read extensively to find commonalities and themes on this topic. The themes that emerged are 'explanation of ICS', 'advantages of ICS', 'disadvantages of ICS' and 'application of ICS in total hip and knee arthroplasty'. Recommendations for perioperative nurses will also be presented with the aim of improving patient health outcomes intra and post-operatively.

Explanation of ICS

ICS is a procedure where blood lost during surgery is collected into a reservoir, heparinised to prevent coagulation, washed, filtered to remove debris, and then safely infused back into the patient.[9,10] Blood is collected using specific aspiration tubing that delivers an anticoagulant during suction to prevent blood from clotting, the blood is delivered straight into a filtered reservoir removing any unwanted debris.[8] The collected blood is then centrifuged to separate the red blood cells from other blood products, the red blood cells are reinfused and the remaining products are discarded.[8] The NBA established that when performed properly by well-trained staff members ICS is an uncomplicated, reliable and economic option for lowering the need for donor transfusion.[8]

The Association of Anaesthetists in the United Kingdom (UK) published a set of guidelines in 2018 which included that cell salvage (CS) should be used when it can lower the possibility of allogeneic transfusion and anaemia post-operatively or where expected blood loss may be more than 500 ml or more than 10 per cent of the patient's circulating blood volume.[1,2,11] The guideline also advocates for CS being used more extensively and made available in all hospitals where major procedures are conducted.[1] In Australia, however, although the NBA's ICS guidance has been based on the UK Cell Salvage Action Group policy document for the provision of ICS, it still follows the American Association of Blood Banks (AABB) recommendation on the use of ICS in cases with expected substantial blood loss which they defined as larger than 20 per cent of the patient's calculated blood volume or roughly one litre in adults.[8] Along with ICS, other patient blood management measures must also be undertaken and these include bloodless surgery, use of clotting agents and other blood conservation measures.[1,8] The ACSQHC reiterate that it is imperative that the patient's own blood be capitalised so that the patient will be less exposed to the risks of donated blood and the corresponding dangers related to transfusion.[1]

Advantages of ICS

The advantages of ICS relate to availability and biochemistry of donor blood and possible complications associated with transfusion. One study found that ICS reduced the use of allogeneic blood by 39 per cent and conserved an estimated 0.68 units for every elective adult perioperative patient.[12] Another study found that ICS has many advantages including reducing necessity for allogeneic blood transfusion, avoiding confining transfusion measures due to blood management principles, providing high-calibre delivery of oxygen in contrast with homologous blood, and avoiding detrimental effects to immunity.[10,13] The ICS method enables red blood cells to maintain their elliptical profiles with elevated concentrations of 2,3-diphosphoglycerate and ATP and physiological pH balance culminating in better oxygen distribution and delivery to the tissues.[10,14] Allogeneic blood causes transfusion reactions precipitating haemolytic reactions and immunosuppression which could prompt higher post-operative infection rates.[2,10,12–15]

Autologous blood is the accepted alternative to donated blood in certain cultures and religions.[6,10] Research has also demonstrated that ICS is more economical compared to donated blood for health care organisations, especially when the blood collected is more than one unit of blood.[12] Using the patient's own blood also avoids viral illnesses[2] and maintains potassium density.[15] The risk of transfusing the wrong type of patient blood is also eradicated and, since ICS does not need any pre-operative planning, it is the ideal choice for unforeseen major blood loss.[2,15] The technology needed for cell salvage has become better over the years and it now comes as smaller programmable units, with reasonable consumables and uncomplicated instructions for the fill, wash and empty sequences.[16] The overall benefits of ICS include lower morbidity, better recovery and sooner mobility and discharge.[10]

Disadvantages of ICS

The disadvantages of ICS relate to cost and resources as well as possible complications from the process. The initial set-up can be costly for hospitals acquiring a salvage machine and there is an ongoing cost of disposables.[7,10,17] The perioperative unit also needs to allocate extra resources to not

only train certain nursing staff to operate and manage the ICS device but also ensure training is adequate and yearly competencies are met.[10] Furthermore, the processing of autologous blood can be slow which may be an important factor in time-sensitive cases where the need for blood is urgent, as in cases of trauma with massive bleeding.[10]

While the cause is undetermined, reinfusion hypotension can occur in certain cases possibly due to the release of bradykinin and sudden low calcium levels.[10] When hypotension occurs, it may be necessary to cease the transfusion and address the hypotension with vasopressors.[10] Other complications may include haemolysis, haematuria, micro-embolism and contamination with drugs or infectious materials.[13] In addition alcohol, hydrogen peroxide and certain hypotonic compounds can cause degeneration and breakdown of red blood cells so ICS is contraindicated when these are factors.[11]

Application of ICS in total hip and knee arthroplasty

A study by Forrest et al.[12] conducted in 2019 at a tertiary hospital in Australia, compared red cell recovery in seven surgical subspecialties, and found that orthopaedic surgery was the specialty that used ICS the most, at 22.9 per cent. The National Institute for Health and Excellence (NICE) recommend that ICS be contemplated in cases with an expected profuse amount of bleeding such as cardiac, open abdominal surgery, complicated urology, obstetric surgery and orthopaedic surgery.[1,18] In a meta-analysis of surgical site infection (SSI) and its relation to blood transfusion, Kim et al.[5] found that allogeneic blood transfusion can increase a patient's risk for SSI. Everhart et al.[19] obtained similar results, stating that there is an increased risk with more units of allogeneic blood transfused.

Approximately 70 per cent of patients who have undergone total knee arthroplasty (TKA) and total hip arthroplasty (THA) have received blood transfusions.[19] While the percentage of patients who develop an SSI may be low (2.00–3.00% for TKA and 1.74–2.88% for THA), the number of cases is significant enough considering how often hip and knee arthroplasty's are currently being performed.[5] These results may suggests that homologous transfusion should be avoided, where possible, in the perioperative setting.[5] The NBA recommends that THA and TKA be classified as surgeries with reduced benefits from ICS; however, revision THA has a higher classification suggesting immense benefits from ICS.[8]

An audit of 100 successive combined orthopaedic surgeries at a small regional private hospital in Australia, conducted by Grace and Lawler[16] in 2020, reported an average return volume of 148 ml in 86 patients who received ICS and a median of 283 ml that varied from 0 to 470 ml. Only six per cent of patients needed allogeneic blood transfusion which was estimated to cost approximately AUD$400 per patient, not including the ancillary costs of cross matching, blood transportation and storage, and other clinical adverse events.[16] The ICS consumables cost approximately AUD$300 for every patient and while initial expenditure for the set up can be costly, this expense is lessened when dispersed across many patients over time.[16]

In another audit of two Australian tertiary hospitals, Forrest et al.[12] found that the orthopaedic specialty used ICS the most (22.9% of cases), closely followed by urology (19.1%) and cardiothoracic surgery (18.6%). Of the procedures that used ICS the most, revision THA ranked first at 7.6 per cent and primary THA fourth at 6.6 per cent.[12] Knee replacement was categorised under 'some benefit' which produced more than or equal to half a unit of red blood cells (a unit is equivalent to 258mls).[12] Although Forrest et al.'s results were consistent with NBA guidelines to not routinely use ICS for primary THA as it produced only less than one unit of blood, others would argue that it produced 200 to 400 mls.[12] Forrest et al.[12] hypothesised that their results may be due to improved blood management and surgical conservation techniques. Miller et al.[17] found that using ICS and tranexamic acid (TXA) together did not enhance blood loss or transfusion results compared to using TXA only. They further suggested that routine ICS in primary THA is an unnecessary expense with no determined medical merit although ICS may be of more value in revision hip surgery.[17] This is supported by Newman et al.'s study, that found that revision THA has approximately 855.8 ml more blood loss than primary THA.[20]

In revision arthroplasty where metalwork may be present, care should be taken during ICS as there is evidence that the 40 micron filters in standard ICS will not eradicate the tiniest particle of titanium.[1,10] However, ICS can still be used after all metal implants have been removed and the area has been thoroughly irrigated.[1,9] Clinicians should also pause ICS during the bone cementing process and resume once the cement has fully set.[10] In a study on chronic hip periprosthetic

joint infection (PJI), Liu et al.[4] found that during the reimplantation surgery in two-stage replacement, ICS was not shown to have led to increased rate of reinfection and revealed a lowered need for allogeneic blood transfusion.

Recommendations for perioperative nursing practice

- Hospitals conducting major surgeries are encouraged to create a team of blood management champions who can collectively determine and establish a set of protocols for the effective implementation of patient blood management strategies.[8]
- Carroll and Young[10] recommend that the use of ICS should be discussed during the WHO surgical team huddle. It is therefore recommended this be included in the set of protocols being developed.
- A review of tranexamic acid used in conjunction with ICS is advised as part of the patient blood management strategies.[11,21] More evidence is showing that allogeneic blood may lead to extended length of hospitalisation and considerable morbidity in certain patient groups.[21]
- When using ICS, it is recommended that the scrub nurse and assistant must help the surgeon to ensure that antibiotics and other haemostatic agents are not suctioned during ICS.[15]
- Carroll and Young[10] also suggest a prompt reinfusion because of possible deterioration of rescued oxygen carrying capacity and deformation of red blood cells over time. It is therefore recommended that the time between removal of blood and reinfusion be kept to an absolute minimum.
- It is recommended that only trained personnel operate the ICS machine. An autotransfusionist is the person who conducts the collection and recycling of the blood; this may be an anaesthetist, an anaesthetic technician, a perfusionist or a nurse who has received the proper training to be able to operate the ICS device.[9]
- An ongoing training and evaluation program, in conjunction with continued data gathering and routine reviews,[2] needs to be implemented to ensure currency of practice including updated learning about new information and changes to ICS technique.[8]

Conclusion

Although homologous or allogeneic blood is a vital and invaluable commodity, it may be inaccessible due to its limited availability or when major blood loss was not anticipated and, despite its benefits, has the potential to transmit viral illness, produce haemolysis and transfusion reactions and cause periprosthetic joint infection in arthroplasties.

ICS plays a vital role in patient blood management and could be used more frequently to optimise outcomes for patients. The cost of setting up ICS is significant due to the expenses of purchasing the equipment, consumables and cost involved in training and providing staff to operate the ICS machine. However, fiscal research that calculated the initial outlay, across patients over time, could compare this cost with the cost of complications and extended hospitalisation over the same period.

Despite some limitations, the benefits of ICS appear to outweigh the costs. In Australia, where knee and hip replacements appear to be common in the older population with other comorbidities, it is of importance that hospitals have properly outlined patient blood management practices in accordance with the national standards. In a world of sustainability and recycling, why would we not consider recycling our most valuable and rare commodity – blood!

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