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A 10-year single-center audit of cell saver use in cardiac surgery

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Abstract

Background/Aim: The use of cell saver technology has revolutionized the management of blood in cardiac surgery, with the objective of reducing the need for allogeneic blood transfusions and enhancing patient outcomes. This study presents a 10-year audit of cell saver use in cardiac surgeries at a tertiary cardiothoracic center in Scotland.

Methods: An analysis of data from cardiac surgery cases using cell savers was conducted. The study assessed the quantity of anticoagulant used, the processing of blood, and the recovery of red blood cells.

Results: The center consistently employed heparin as the anticoagulant during the review period. The mean age of the 1717 patients was 56.85 years; 66.86% were male and 33.14% were female. The mean blood processed volume was 1646.55 ml and the mean salvaged red cell volume was 544.22 ml over a 10-year period. The deployment of cell savers was most prevalent during coronary artery bypass graft surgeries and major aortic procedures.

Conclusion: The potential to minimize blood loss and reduce allogeneic blood transfusions is present in cell saver technology for cardiac surgery. The significance of optimizing cell saver protocols to enhance patient care and efficacy is underscored in the study.

Keywords: cell saver, cardiac surgery, transfusion

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Ethics Committee Approval
The study was approved by the Institutional Review Board of Golden Jubilee National Hospital (approval number 2087).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Introduction

Over the past decade, cell salvage techniques in cardiac surgery have gained attention. This is due to its strategic role in patients for whom allogeneic blood transfusions are contraindicated. Allogeneic blood transfusions are vital to surgical procedures but come with risks and challenges. Thus, autologous blood donation before surgery and cell salvage methods to limit allogeneic blood product transfusion have become more popular.

The historical evolution of cell saver devices, especially in relation to perioperative care, represents a notable change in surgical strategies employed for blood conservation. Haemonetics unveiled the first commercial blood salvage device, the Cell Saver, in 1974 [1], therefore, marking a turning point in the discipline of transfusion medicine. The phrase "cell saver" has changed throughout time to refer to a larger class of blood salvage equipment used in different surgical environments, especially where significant blood loss is expected [2].

In cardiac surgery, cell saver technology has changed blood management to reduce allogeneic blood transfusions and improve patient outcomes. Cardiothoracic surgeries utilize a substantial portion of allogeneic red blood cells [3,4]. In the United Kingdom, roughly 10% of the blood supplied by the National Blood Service is used for cardiac surgery [5]. The state of intraoperative cell salvage use in cardiac surgery across the UK was highlighted by the 2021-2022 survey conducted by the UK Cell Salvage Action Group (UKCSAG) [6]. This survey aimed to evaluate existing practices and revealed that cell savers were widely utilized in various surgical specialties. In cardiac surgery, approximately 89% of responding cardiac units reported its use.

Cell-saver autologous blood transfusions involve obtaining and re-infusing the patient's blood either during or after surgery [7]. Many surgical disciplines, including cardiac surgery, orthopedics, and vascular surgery [1], find several benefits for this method.

Alternatives to homologous transfusions are needed due to fewer blood donors and rising blood product prices [5]. Blood conservation recommendations state that homologous blood transfusion in cardiac surgery is an established approach to lower blood loss [8]. The investigation of autologous blood donation, cell salvage technologies, and other blood management modalities has paved the way for the reduction of hazards associated with allogeneic blood transfusions, as well as the acquisition of a more thorough understanding of how to maximize patient outcomes. This 10-year review examines the use and efficacy of cell savers in cardiac procedures at a Scottish cardiothoracic institution.

Materials and methods

This retrospective analysis encompassed individuals who underwent cardiac surgery at a Scottish regional cardiothoracic center over a 10-year period. All patient data were processed in accordance with the Declaration of Helsinki and the UK National Health Service Research Ethics Committee standards. In order to safeguard the privacy of individuals, the investigation implemented rigorous anonymization protocols. This entailed the elimination of all identifiable information prior to data analysis and the assignment of unique identifiers while maintaining patient confidentiality. In accordance with the guidelines regulating retrospective data analysis, patient consent was waived in accordance with the NHS Health Research Authority policy for Scotland.

The audit included data from January 1, 2013 to January 1, 2023, with an emphasis on information gathered from the perfusion unit. Individuals who underwent cell salvage following cardiac surgical procedures met the inclusion criteria. Out of 2354 instances spanning a decade, 63 had missing data, 572 had insufficient volume processing (less than 600 ml for most cases), and three had red cells discarded owing to poor washing, leaving 1717 cases for final analysis.

The type of anesthesia employed, pulmonary artery catheterization, intraoperative monitoring measures, and transfusion strategy were all managed according to institutional standards. The operational roles for cell saver use in the institution were carried out by perfusionists and involved periodic evaluations and equipment checks. Heparin was always the preferred anticoagulant.

The audit team comprised a clinical teaching fellow (MO) and cardiac surgeon (ZM) with two perfusionists assisting in sourcing the data. The study focused on anticoagulant volumes, blood processing, and red cell salvage. The documentation also contained a breakdown of instances by year and the procedures used.

Statistical analysis

Statistical analysis was performed using Microsoft Excel (version 2010). Descriptive statistics were used to summarize patient characteristics, using mean, standard deviation, and percentage. A statistical significance value of <0.05 was used for two-tailed *P*-value.

Results

The study included and singularly audited a total of 1717 patients who underwent cardiac surgery over a 10-year period. Table 1 shows patients' sex and mean age. Of these patients, four were Jehovah's Witnesses, who typically refuse consent for blood transfusion due to religious reasons.

Table 1: Patient demographics.

Variable	Value
Age, Mean (SD)	56.85 (17.46)
≥60 years, n (%)	861 (50.15)
<60 years, n (%)	856 (49.85)
Sex	
Male, n (%)	1148 (66.86)
Female, n (%)	569 (33.14)

The data on anticoagulant amounts, blood processed, and red cells salvaged are outlined in Table 2.

Table 2: Cell saver metrics.

	Volume of anticoagulant used (ml)	Volume of blood processed (ml)	Volume of salvaged red cells (ml)
Minimum	30	63	70
Maximum	11,173	11,633	4,680
Total	1,044,552	2,827,132	934,417
Mean (SD)	608.36 (432.39)	1646.55 (1394.56)	544.22 (479.87)
Median	500	1,308	440

Table 3 below shows the comparison of salvaged red cells by age and sex, with the operations involving males returning more cell salvage (*P*=0.009)

Table 3: Comparison of salvaged cells by age and sex.

Variable	Volume of Salvaged cells	*P*-value
Age		0.466
≥60 years	464999	
<60 years	469418	
Gemder		0.009
Male, n (%)	645506	
Female, n (%)	288911	

Figure 1 below indicates fluctuations in the number of cases over the years, with a peak in 2022. Figure 2 shows the distribution of volumes by year. The distribution of cases by procedure shows that "Other Major Aortic" procedures had the highest number of cases, followed by aortic valve replacement and coronary artery bypass graft (CABG) (Table 4).

Figure 1: The distribution of cases by year.

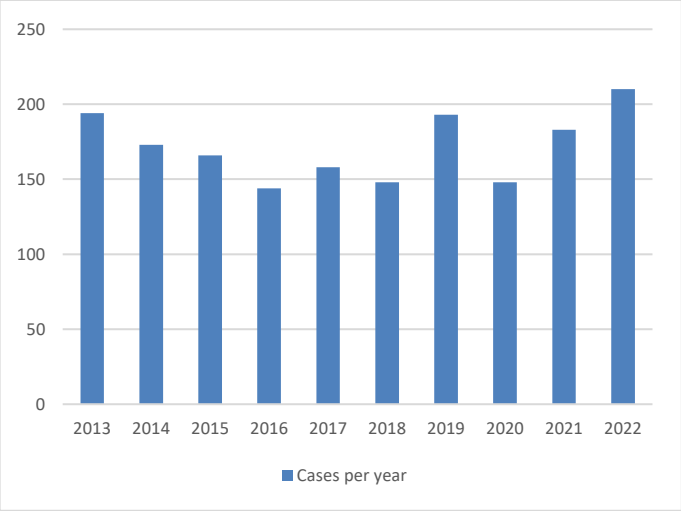
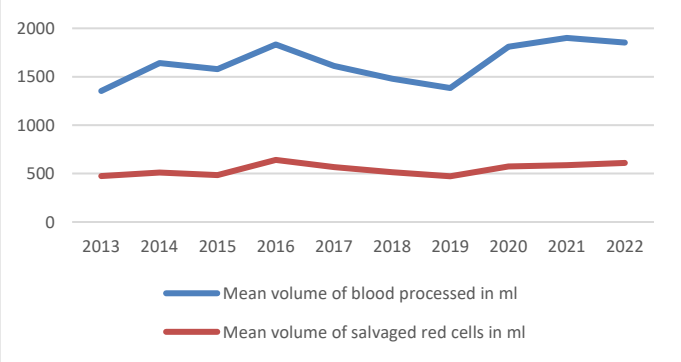


Figure 2: The distribution of volumes by year.



From figure 2 above, statistical comparison between the mean volumes of salvaged cell for the year with the minimum (2019) and maximum (2016) was not significant (2.821).

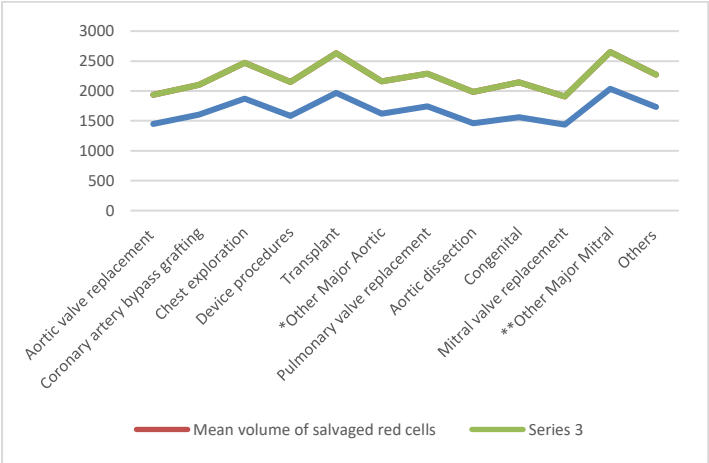
The comparison of cases by volume is presented in the chart below (Figure 3).

Table 4: The distribution of cases by procedure.

Procedure	Number of cases	Percentage
Aortic valve replacement	283	16.48%
Coronary artery bypass grafting	161	9.38%
Chest exploration	136	7.92%
Device procedures	122	7.11%
Transplant	120	6.99%
***Other Major Aortic**	423	24.64%
Pulmonary valve replacement	66	3.84%
Aortic dissection	103	6.0%
Congenital	60	3.49%
Mitral valve replacement	53	3.09%
****Other Major Mitral**	89	5.18%
Others	101	5.88%

* Repair or replacement of any part of the aorta, aortic stenting, Ross procedure, aortic valve repair, aortic valve replacement plus one or more major cardiac procedures
** Mitral valve repair, mitral valve replacement plus one or more major cardiac procedures

Figure 3: The comparison of cases by volume



Discussion

The context of cardiac surgery, with its high use of allogeneic blood products and related dangers, has fueled research into various techniques to lessen reliance on allogeneic transfusions [9]. These techniques include iron supplementation, pharmaceutical therapies, better surgical hemostasis, and cell salvage [10]. Despite the reality that the hazards of blood transfusions have lessened over time, the scarcity and expensive cost of blood necessitates its careful usage [11]. This is exacerbated by the decline in donor availability, which was made worse by the COVID-19 pandemic. Reports show that blood donation rates plummeted by as much as 40% in certain regions due to the cancellation of donation drives and public health concerns [12]. The argument centers on assessing the risks and costs of treatments aimed at reducing transfusion requirements, with cell salvage emerging as a contentious but promising option.

The Society of Thoracic Surgeons and The Society of Cardiovascular Anesthesiologists published a guide for blood transfusion and conservation in cardiac surgery [11]. There are six key variables that increase risk: advanced age, low preoperative red blood cell volume (anemia or small body size), preoperative antiplatelet or antithrombotic medications, re-operative or difficult procedures (such as aortic and congenital procedures), emergency surgeries, and non-cardiac patient comorbidities. Not surprisingly, our audit suggests that major aortic surgeries accounted for the largest use of cell savers in our center.

Numerous studies have investigated the efficacy of cell saver technology in cardiac surgery. In the context of patient blood management, where strategies to reduce dependence on allogeneic blood are increasingly common, autologous blood salvage remains a valuable tool for perioperative blood conservation [1]. Studies have shown that the use of a cell saver reduces exposure to allogeneic blood products and red blood cell transfusions in patients undergoing cardiac surgery [8,13-15]. Even in situations where the use of cell savers was not cost-effective due to the relationship between cell savers and packed cell costs, there are evident benefits for patients, such as a shorter hospital stay [16]. The peculiarities in how this process is executed, such as continuous versus discontinuous processing and variations in washing techniques, can impact patient outcomes. The choice of cell salvage device and the timing of its use during and after surgery are crucial factors that influence the effectiveness of this technique [10].

The cost implications associated with using cell saver technologies in cardiac surgery are multi-faceted. From direct charges, indirect costs, and the possibility for cost savings through lowered transfusion requirements, the financial effects can be viewed from several angles. Using cell savers for intraoperative cell salvage was significantly linked, according to a recent observational analysis, with a reduction of allogeneic RBC transfusions—with a decrease of up to 52% in patients experiencing significant blood loss [15]. Given the costs and risks of transfusing stored blood—which include adverse reactions and outcomes like febrile non-hemolytic transfusion reactions and transfusion-related infections—this decrease is noteworthy [17]. Transfusion reactions can create a major financial burden involving long-term effects of patient morbidity as well as urgent medical expenses. Along with instant savings on blood supplies, this decrease in expenses related to transfusion-related issues yields positive prospects.

Given the robust evidence on the efficacy of cell savers, their use is not without risk. One study highlighted that large volumes of cell-salvaged blood could lead to coagulopathy due to dilution of coagulation factors, activation of fibrinolysis, and residual heparin presence despite the washing process during cell salvage [18]. The authors suggested that a cell salvage volume exceeding a certain threshold could significantly impair fibrin polymerization, potentially necessitating supplementation with fibrinogen concentrate or cryoprecipitate in patient bleeding post-cardiopulmonary bypass.

Safety concerns for cell saver devices include infection risk, transfusion need reduction, and patient outcomes. One of the biggest cell saver device safety concerns is bacterial contamination of reinfused blood. In cardiac surgery patients, red blood cells from cell saver systems can cause bacteremia [19]. This danger is increased with cardiopulmonary bypass (CPB), when blood manipulation can introduce pathogens. Cell savers should be used cautiously in high-risk postoperative cardiac patients due to the unknown source of infections. Although regular antibiotics are used to treat these infections, cell saver systems must be constantly monitored and researched to minimize such repercussions [19]. Preoperative colonization assessment, aseptic techniques, cutting-edge monitoring methods, and sterilization procedures can further reduce these hazards, ensuring that cell saver technology benefits patients without endangering their safety.

In a contrasting study focusing on pediatric cardiac surgical practice, it was highlighted that reinfusion of autologous blood collected by these devices does not raise the risk of hospital-acquired infections or mortality [20]. Given the susceptibility of young patients who are typically undergoing difficult surgical treatments, this result is very important. This reinforces the idea that, when properly controlled, cell saver devices can be safely adopted into the surgical workflow for this demographic. Notwithstanding the benefits, the safety profile of cell saver devices needs constant assessment, especially in view of new data about their use in high-risk surgical operations.

Research on cell salvage has primarily focused on intraoperative interventions and outcomes during the index admission, including the reduction in allogeneic blood transfusions. Meta-analyses and randomized controlled trials have provided insights into the efficacy of cell salvage, with varying conclusions on its impact on transfusion requirements and patient outcomes. While some studies have reported advantages of cell salvage in reducing allogeneic blood product exposure, others have presented conflicting results, underscoring the need for further research and consensus in this area [10].

Jehovah's Witnesses, who typically refuse consent for blood transfusions due to religious reasons, find cell savers to be a viable solution in these challenging situations. The results of a review, which described and compared the cardiac surgery outcomes of Jehovah's Witness patients to non-Jehovah's Witness patients in various case reports, case series, and comparative cohort studies, support this. Many of these studies found no significant differences in the outcomes of the two groups for variables like mortality [21]. However, it is important to emphasize the legal and ethical challenges faced by medical professionals in managing Jehovah's Witness patients undergoing cardiac surgery. The importance of respecting patient autonomy and providing alternative treatments to blood transfusion should be emphasized [20].

The choice of anticoagulant can affect the quality of salvaged red cells and subsequent patient outcomes [22]. Heparin is better than citrate as an anticoagulant during auto-transfusion with cell washing and immediate re-transfusion [23]. This was determined in a study that compared the quality of washed, salvaged red blood cells during total hip replacement surgeries. The median volume salvaged is similar to that in a study, in which results suggested that there was an opportunity to use blood salvage more selectively to improve efficiency, especially in certain surgical procedures.

Accommodating the development of cell saver technology has required continuous study aimed at optimizing the related operations. For instance, a study of the washing solutions applied in cell saver systems found that the solution choice might greatly affect the quality of the obtained red blood cells (RBCs). The findings showed that washing using a bicarbonate-buffered solution not only improved electrolyte balance but also lowered RBC lysis, implying that refining cell saver techniques could help to improve patient outcomes even more [24]. This exposes the need of ongoing development in the approaches related to the usage of cell savers since it directly relates with the effectiveness of blood conservation policies in cardiac surgery.

The operational dynamics of using cell savers have changed; specialized practitioners are now hired to maximize the intraoperative cell salvage procedure. This contrasts with past practices in which anesthesiologists concurrently handling other jobs during surgery generally provided the responsibility of running cell savers. Particularly in high-stakes events involving significant blood loss [25], the creation of specific positions for cell salvage practitioners has proven to strengthen the efficiency and effectiveness of blood recovery procedures. This development in practice emphasizes the need of the human elements influencing the deployment of the technology in clinical environments as well as its inherent nature.

Various factors, including advancements in surgical techniques, changes in patient demographics, and improvements in perioperative care, have contributed to the fluctuations in the number of cases over the years. The impact of the COVID-19

pandemic on the use of cell saver technology in 2020 is evident from the decrease in cases compared to previous and subsequent years. The pandemic caused disruptions in healthcare services, including elective surgeries, which likely contributed to a decrease in cardiac surgery cases utilizing cell saver technology.

Overall, the significant volume of processed blood and red cells salvaged over the 10-year period demonstrates the potential impact of cell saver utilization on reducing the need for external blood products. Furthermore, cases with inadequate processing volume highlight the importance of optimizing cell saver protocols, as properly washing red blood cells reduces postoperative inflammation and transfusion requirements in cardiac surgery [24].

Some insights into the positive influence that this technology has had on patient care are provided by the audit of the use of cell savers in cardiac surgery. This technique emerges as a useful asset since it lessens the requirement for allogeneic blood transfusions, minimizes the amount of blood that is lost during surgery, and has the potential to improve postoperative results. Optimizing the use of cell savers depends on continual research and clinical care to guarantee improved patient outcomes in the high-stakes field of cardiac surgery.

The discussions around the use of cell salvage in cardiac surgery underscore the complexity of balancing the benefits and risks of different blood conservation techniques. Standardizing the approach to cell salvage through well-designed multicenter studies with specified devices is essential in evaluating the long-term advantages and cost-effectiveness of implementing cell savers in a cardiac surgical setting. We can interpret findings in a broader context by integrating findings from relevant literature on cell saver efficacy, blood conservation strategies, and perioperative outcomes in cardiac surgery.

There are certain limitations that must be considered in this study. These constraints are exacerbated by the single-center audit, as the results of a single institution may not be pertinent to larger populations. The study's retrospective approach has the potential to introduce selection bias, and the capacity to draw definitive conclusions is restricted by the absence of comprehensive outcome measurements. Determining a causal relationship between the variables is challenging due to the retrospective nature and single-center context. The absence of causal inference and the potential for selection bias necessitate an interpretation of the connections as hypothesis-generating and preliminary rather than definitive.

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