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Reduce intraoperative albumin utilisation in cardiac surgical patients: a quality improvement initiative

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ABSTRACT

Background Albumin continues to be used routinely by cardiac anaesthesiologists perioperatively despite lack of evidence for improved outcomes. The Multicenter Perioperative Outcomes Group (MPOG) data ranked our institution as one of the highest intraoperative albumin users during cardiac surgery. Therefore, we designed a quality improvement project (QIP) to introduce a bundle of interventions to reduce intraoperative albumin use in cardiac surgical patients.

Methods Our institutional MPOG data were used to analyse the FLUID-01-C measure that provides the number of adult cardiac surgery cases where albumin was administered intraoperatively by anaesthesiologists from 1 July 2019 to 30 June 2022. The QIP involved introduction of the following interventions: (1) education about appropriate albumin use and indications (January 2021), (2) email communications reinforced with OR teaching (March 2021), (3) removal of albumin from the standard pharmacy intraoperative medication trays (April 2021), (4) grand rounds presentation discussing the QIP and highlighting the interventions (May 2021) and (5) quarterly provider feedback (starting July 2021). Multivariable segmented regression models were used to assess the changes from preintervention to postintervention time period in albumin utilisation, and its total monthly cost.

Results Among the 5767 cardiac surgery cases that met inclusion criteria over the 3-year study period, 16% of patients received albumin intraoperatively. The total number of cases that passed the metric (albumin administration was avoided), gradually increased as our interventions went into effect. Intraoperative albumin utilisation (beta=−101.1, 95% CI −145 to −56.7) and total monthly cost of albumin (beta=−7678, 95% CI −10712 to −4640) demonstrated significant decrease after starting the interventions.

Conclusions At a single academic cardiac surgery programme, implementation of a bundle of simple and low-cost interventions as part of a coordinated QIP were effective in significantly decreasing intraoperative use of albumin, which translated into considerable costs savings.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Albumin continues to be used routinely by cardiac anaesthesiologists despite lack of evidence for improved outcomes compared with crystalloids. The Multicenter Perioperative Outcomes Group (MPOG) data ranked our institution as one of the highest intraoperative albumin users during cardiac surgery compared with other participating institutions.

WHAT THIS STUDY ADDS

⇒ We introduced a bundle of educational and low-cost interventions at our single academic medical centre, that managed to significantly decrease intraoperative albumin utilisation, translating into considerable annual cost savings.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Quality improvement project teams can leverage the feedback provided by MPOG quality measures to fine tune their interventions and improve their institutional performance on different MPOG quality metrics.

INTRODUCTION

Adequate intravenous fluid resuscitation is crucial during cardiac surgery to maintain adequate tissue perfusion.[1] However, the optimal fluid to administer remains controversial with significant variation in clinical and institutional practices.[2] While more than half of cardiovascular anaesthesiologists and cardiac surgeons in the US reported that balanced crystalloid solutions are their preferred first line choice for volume expansion in cardiac surgical patients not experiencing significant blood loss, over one third still considered albumin to be their first fluid choice.[3] This continued routine use of albumin is rooted in firm belief among some practitioners that albumin is a better fluid expander than crystalloids and that it has protective effects on the endothelial glycocalyx.[4]

The ALBICS (Albumin in Cardiac Surgery) trial recently compared albumin with a balanced crystalloid solution and reported no difference in major adverse events including mortality.[5] The debate of colloid vs crystalloid fluid resuscitation will surely continue, but

there is enough evidence to support stopping routine use of albumin given that it lacks clear benefit in both effectiveness and safety in fluid resuscitation of cardiac surgical patients, in addition to its higher cost.[6] After reviewing relevant literature and practice guidelines, the American Society of Anesthesiologists (ASA) released the Choosing Wisely campaign, with a list of evidence-based recommendations that included avoidance of routine administration of colloids for volume resuscitation in the absence of clear indications.[7]

The Multicenter Perioperative Outcomes Group (MPOG) is a group of over 70 hospitals, with a stated mission of promoting research, education and quality improvement (QI) to provide safe, evidence-based perioperative patient care. The data collected by the MPOG group represent the most comprehensive global anaesthesia perioperative registry. MPOG provides monthly data on QI measures to participating institutions, in addition to individualised feedback reports to anaesthesia providers.[8 9] MPOG data demonstrated that our institution has been one of the highest intraoperative albumin users during cardiac surgery compared with other MPOG participants.

Our QI team was composed of the anaesthesiology department's director of quality and safety, cardiac anaesthesiologist, pharmacist and a biostatistician. The team aimed to leverage the monthly feedback provided by MPOG to improve our institutional performance on the metric of minimising colloid use in cardiac surgery cases. We hypothesised that a quality improvement project (QIP) that introduced a bundle of interventions would be associated with a reduction in the proportion of cases receiving albumin during cardiac surgery.

METHODS

After obtaining institutional review board approval, we queried MPOG for data submitted from our institution; a large quaternary academic medical centre over a 3-year period from 1 July 2019 to 30 June 2022. The MPOG data direct tool was used to identify our study cohort of adult patients that underwent cardiac surgery.

Primarily, we collected data on the FLUID-01-C QI measure which aims to minimise colloid use in cardiac surgery.[10] A case passed the FLUID-01-C measure if a colloid was not administered intraoperatively. Preoperative and postoperative albumin use is neither collected or evaluated by this MPOG measure, nor was it the focus of our interventions. It is worthy to mention that at our institution, the only available colloid is albumin, and any reference to colloid administration in this study implies albumin. This QI measure has built in exclusion for non-cardiac cases, ASA 5 and ASA 6 cases, ≥2 L estimated blood loss, ≥4 units of packed red blood cells (PRBC) transfused, prone or Trendelenburg position for >4 hours, and patients with ascites. This represented the initial cohort of cardiac surgical cases as defined by MPOG. Baseline data on our institution's performance on the FLUID-01-C measure compared with other anonymised MPOG institutions were collected for the initial cohort of cardiac cases before starting our first study intervention in January 2021. We further excluded patients <18 years of age, and cases not performed by the adult cardiothoracic surgical service because MPOG includes anaesthetic cases performed in the cardiac catheterisation lab, electrophysiology suite, cardiac MRI and cardiac diagnostics unit as cardiac cases evaluated by the FLUID-01-C measure. Additionally, we collected baseline characteristics such as age, sex, race and ASA Physical Status for our cohort of patients, as well as intraoperative variables such as crystalloid utilisation and receipt of PRBC, fresh frozen plasma (FFP) and platelets.

This QIP involved the introduction of a bundle of interventions in a staggered manner to reduce intraoperative albumin use in cardiac surgical patients: (1) education about appropriate albumin use and indications (started January 2021; online supplemental educational material), (2) email communications that were reinforced with OR teaching (started March 2021), (3) removal of albumin from the standard pharmacy intraoperative cardiac medication trays (April 2021), (4) grand rounds presentation discussing the QIP and highlighting the previous interventions (May 2021) and (5) quarterly provider feedback (starting July 2021). In addition to tracking cases where albumin was administered, the total monthly cost was provided by the pharmacy department to track total expenditure on albumin over time.

Statistical analysis

Descriptive statistics, counts (percentage) for categorical and median (Q1, Q3) for continuous variables were used to compare patient baseline characteristics and intraoperative variables by preintervention and postintervention periods. The difference of preintervention and postintervention characteristics are tested using χ^2 test and Wilcoxon rank-sum test. We calculated albumin cost by multiplying used albumin grams and the monthly cost/gram price. In addition to our primary outcome of albumin utilisation, total monthly albumin cost and rate of passing an acute kidney injury MPOG QI measure (AKI-01) were evaluated. Passing the AKI-01 measure signifies that the patient's creatinine level did not go above 1.5 times the baseline creatinine value within 7 days postoperatively or the creatinine level did not increase by ≥0.3 mg/dL within 48 hours after anaesthesia end.[11] Patients meeting MPOG built in exclusion criteria for AKI-01 are excluded from the analysis of AKI-01 outcome.

Univariate analysis was also performed on outcomes to examine the preintervention and postintervention differences. Interrupted time series analysis (ITSA) was performed using multivariable segmented linear and logistic regression model to assess the effect of interventions on outcomes. Baseline and intraoperative characteristics with p value less than 0.15 were included in the ITSA model as covariates. The first intervention in January 2021 was used as the intervention timepoint in the analysis and

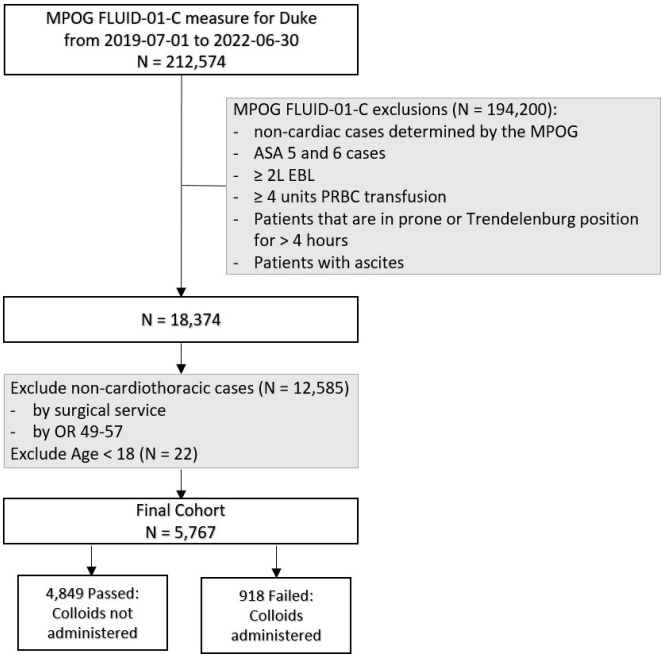

Figure 1 Consolidated Standards of Reporting Trials flow diagram of study cohort. ASA, American Society of Anesthesiologists; EBL, estimated blood loss; MPOG, Multicenter Perioperative Outcomes Group; PRBC, packed red blood cells.

p<0.025 was considered statistically significant of effective intervention. Statistical analysis was conducted using R V.4.2.3.

RESULTS

A total of 212 574 anaesthetic cases were performed at our institution from 1 July 2019 to 30 June 2022, according to data provided by MPOG. 194 200 cases met the MPOG built in exclusion criteria for the QI measure of FLUID-01-C (minimising colloid use in cardiac cases). The remaining 18 374 patients represented the initial cohort of cardiac cases as defined by MPOG. To further narrow down on the cardiac surgical population, we excluded patients <18 years old, non-cardiothoracic surgical cases and cases not performed in our cardiothoracic operating rooms to reach a final study cohort of 5767 cases (figure 1). Baseline comparison of this initial cohort at our institution reported very low FLUID-01-C measure passage rate compared with other MPOG institutions. Those findings were inconsistent with our clinical practice, where some anaesthesia providers who do not use intraoperative albumin received low pass rate for that metric. Our MPOG QI officer examined individual patient charts and identified that MPOG data for the FLUID-01-C measure included colloids administered by perfusionists as well. Our QI officer petitioned for this to be amended on the principle that MPOG performance metrics that evaluate anaesthesiologists should focus on actions that they perform. MPOG polled member institutions and albumin administered by perfusionists was removed from being considered for this measure following agreement within the MPOG Quality Committee. At our institution, anaesthesiologists administer albumin 5% intraoperatively for fluid resuscitation, while albumin 25% is exclusively used by perfusionists to provide Cardiopulmonary bypass(CPB) surface coating, which was reported to reduce platelet loss during CPB.[12] Following this change, our baseline pass rate improved, but remained below the average performance of other MPOG institutions.

Baseline characteristics and intraoperative variables divided by preintervention and postintervention periods are presented in table 1. From the univariable analysis, albumin utilisation (pre: median (Q1,Q3)=100 (0, 250), post: median (Q1, Q3)=0 (0, 100), p<0.001) showed a significant difference between preintervention and postintervention periods while intraoperative crystalloid utilisation (pre: median (Q1, Q3)=3200 (800, 7504), post: median (Q1, Q3)=3316 (730, 7940), p=0.573) showed no significant difference. Among 4918 (pre: N=2440, post: N=2478) patients with AKI-01 measure, the passing rate of AKI-01 measure increased from 72% before intervention to 75.1% after intervention (p=0.013). The ITSA model adjusted for baseline characteristics such as race, preoperative haemoglobin and platelets, preoperative renal failure, and intraoperative receipt of FFP. From the multivariable segmented regression, there was significant decrease in albumin utilisation (beta=−101.1, 95% CI −145 to −56.7) (figure 2 and table 2), and total monthly albumin cost (beta=−7678, 95% CI −10712 to −4640) (figure 3 and table 2) as our interventions went into effect. There was no significant difference in the slope between postintervention and preintervention periods for albumin utilisation and cost. MPOG provided feedback on our institution's FLUID-01-C measure performance compared to other participating institutions, showing improvement as our interventions went into effect, which was maintained until the end of the study period (figure 4). Finally, compared with preintervention, the odds of passing the AKI-01 measure were 77% higher immediately after starting the interventions, but this was not statistically significant (OR=1.77, 95% CI 0.06 to 7.78) (online supplemental figure 1 and table 2).

DISCUSSION

At our single quaternary academic medical centre, among 5767 cardiac surgery cases over a 3-year observational period, 16% of cardiac surgical patients received albumin intraoperatively and 84% did not. As we implemented a staggered bundle of interventions aiming to reduce intraoperative albumin utilisation starting in January 2021, we observed a significant decrease in albumin utilisation and total monthly albumin cost immediately after starting the interventions, and a non-significant difference in the rate of change between postintervention and preintervention periods. Additionally, there was no intervention effect on the passing rate of AKI-01 measure from preintervention to postintervention periods. Our findings demonstrate

Table 1 Patient characteristics and intraoperative variables for the study cohort, divided by preintervention and postintervention periods

	Before intervention N=2946 (51.1%)	After intervention N=2821 (48.9%)	P value
Baseline characteristics			
Age	64.0 (53, 72)	64.0 (54, 72)	0.662*
Female	992 (33.7%)	923 (32.7%)	0.465†
Race			
White	2143 (72.7%)	1987 (70.4%)	<0.001†
Black	622 (21.1%)	691 (24.5%)	
Other	97 (3.3%)	54 (1.9%)	
Unknown	84 (2.9%)	89 (3.2%)	
ASA Physical Status			0.368†
ASA Class 2	12 (0.4%)	7 (0.2%)	
ASA Class 3	490 (16.6%)	496 (17.6%)	
ASA Class 4	2444 (83.0%)	2316 (82.1%)	
Emergency status classification (yes)	352 (11.9%)	325 (11.5%)	0.650†
Preoperative haemoglobin	12.0 (9.8, 13.6)	12.1 (10.1, 13.7)	0.016*
Preoperative albumin	3.50 (2.9, 3.8)	3.50 (2.9, 3.8)	0.929*
Preoperative platelet count	193 (146, 247)	197 (153, 251)	0.036*
Comorbidity elixhauser blood loss anaemia	99 (3.4%)	111 (3.9%)	0.268†
Comorbidity elixhauser renal failure	1197 (40.6%)	1024 (36.3%)	0.001†
Intraoperative variables			
Receipt of PRBC	710 (24.1%)	678 (24.0%)	0.978
Receipt of FFP	300 (10.2%)	346 (12.3%)	0.014
Receipt of platelets	788 (26.7%)	759 (26.9%)	0.916

N (%) for categorical, median (IQR) for continuous variables.
*Wilcoxon rank-sum test.
†χ^2 test.
ASA, American Society of Anesthesiologists; FFP, fresh frozen plasma; PRBC, packed red blood cell.

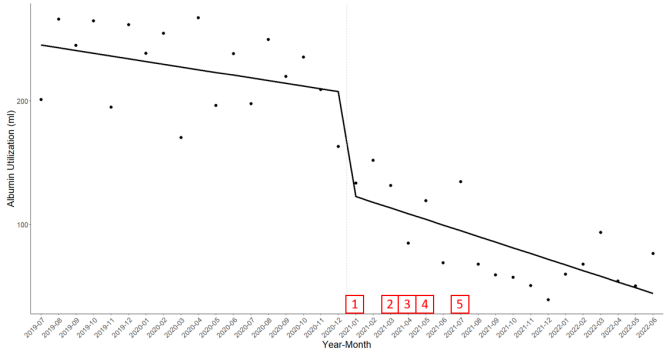

Figure 2 Interrupted time series analysis of monthly albumin utilisation over the study period. Quality improvement project interventions are numbered: 1—education about appropriate albumin use and indications, 2—email communications reinforced with OR teaching, 3—removal of albumin from the standard pharmacy cardiac medication trays, 4—grand rounds presentation and 5—quarterly provider feedback.

that implementation of our interventions was successful in reducing albumin utilisation and total cost.

There has been increasing evidence that albumin utilisation in cardiac surgery with CPB has been associated with various adverse outcomes questioning the value of its use in that setting. The ALBICS trial was a randomised, double-blind superiority trial that compared 4% albumin with Ringer's acetate solution as CPB prime and perioperative IV volume replacement solution. The study included 1386 patients and reported no difference in major adverse events including mortality, concluding that their findings do not support the use of albumin in cardiac surgery. Furthermore, analysis of individual components of the primary outcome composite were underpowered, but reported a significant lower incidence of myocardial injury, and a higher significant incidence of bleeding, reoperation and infection in the albumin group.[5] While increased transfusion of only FFP was observed in our cohort postintervention, increased transfusion of blood

Table 2 Interrupted time series analysis of outcomes

	Time (months)		Intervention		Time post (months)	
	Estimate (95% CI)	P value	Estimate (95% CI)	P value	Estimate (95% CI)	P value
Albumin utilisation (mL)	−1.97 (−4.73 to 0.79)	0.153	−101.08 (−145 to 56.7)	<0.001	−2.74 (−6.86 to 1.97)	0.184
Total albumin cost ($)	−91.6 (−281 to 97.4)	0.327	−7678 (−10 712 to −4640)	<0.001	−40.3 (−323 to 242)	0.771
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
AKI-01 passed (%)	0.99 (0.78 to 1.23)	0.920	1.77 (0.06, 7.78)	0.748	0.98 (0.72 to 1.34)	0.905

Time: months since start of study (1–18 preintervention and 19–36 postintervention).
Intervention: 0 for preintervention, 1 for postintervention.
Time post: 0 in preintervention period and 1–18 postintervention.
AKI, acute kidney injury.

products in cardiac surgical patients receiving albumin has been reported even in the presence of equal chest tube drainage, suggesting that transfusions were secondary to haemodilution.[13] Subsequent studies reported significant increase in both bleeding and transfusion of blood products suggesting direct impairment of coagulation.[5 14] This has been attributed to albumin's antithrombotic and anticoagulant effects, resulting from its capacity to bind nitric oxide, inhibiting its rapid inactivation, and prolonging its antiplatelets aggregation properties.[15] Additionally, while no intervention effect was observed in our cohort on change in the passing rate of AKI-01 measure from preintervention to postintervention periods, albumin administration has been previously associated with dose-dependent increased risk of AKI,[16] and new postoperative dialysis.[17] Hyperchloraemia has been reported to increase the risk of AKI,[18] which has been a concern with albumin because it has variable chloride concentrations in different albumin preparations. An ongoing ALBICS trial is addressing those concerns, and currently investigating the relationship of albumin administration and AKI after cardiac surgery.[19] It is worthy to mention that albumin is a plasma-derived product, which explains some of the concerns about its administration such as in Jehovah's witnesses,[20] and its adverse events, which although being very rare, can range from mild symptoms such as fever, nausea, flushing and mild hypotension to severe anaphylactoid reactions.[21]

Our healthcare landscape is shifting slowly to a value-based system, where fee for service is replaced by fee for value, and hospitals are incentivised to improve the quality and safety of their provided care while reducing cost.[22] This value-based care model has been embraced by leading national healthcare organisations such as the ASA and the American Heart Association.[7 23] Healthcare professionals are encouraged to question the use of medications or interventions that are non-superior in clinical effectiveness in the presence of considerably cheaper alternatives.[24] Like any other costly medication, albumin's cost varies over time and among different institutions depending on the negotiated contract, which makes cost effective analyses difficult to conduct. Irrespective of the exact cost, albumin has been reported to be at least 30–75-fold more expensive than commonly used crystalloid solutions.[25 26] Measuring our monthly albumin utilisation allowed us to calculate cost using data provided by our pharmacy, which translated into considerable annual cost savings in intraoperative cardiac surgical patients alone. Savings are expected to be amplified as the QI

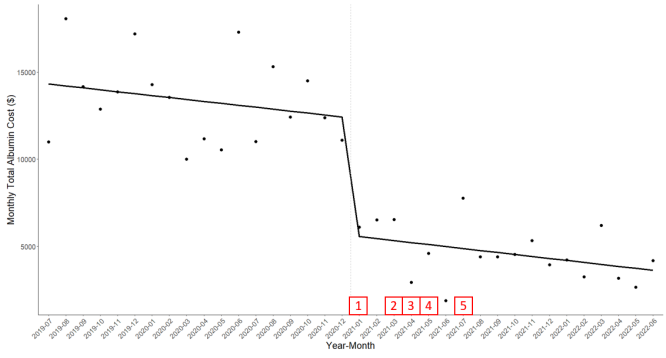

Figure 3 Interrupted time series analysis of total monthly cost of albumin over the study period. Quality improvement project interventions are numbered: 1—education about appropriate albumin use and indications, 2—email communications reinforced with OR teaching, 3—removal of albumin from the standard pharmacy cardiac medication trays, 4—grand rounds presentation and 5—quarterly provider feedback.

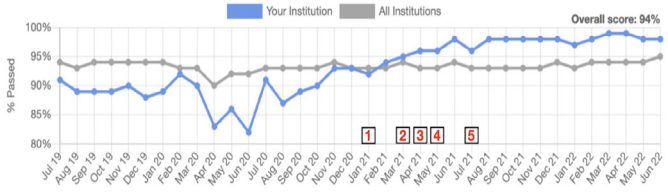

Figure 4 Multicenter Perioperative Outcomes Group (MPOG) dashboard showing intraoperative FLUID-01-C measure on colloid utilisation at our institution compared with other MPOG participating institutions from July 2019 to June 2022. % Passed=percentage of cardiac surgery patients that did not receive albumin. Quality improvement project interventions are numbered: 1—education about appropriate albumin use and indications, 2—email communications reinforced with OR teaching, 3—removal of albumin from the standard pharmacy cardiac medication trays, 4—grand rounds presentation and 5—quarterly provider feedback.

team extend their work to intensive care unit (ICU), and non-cardiac operating rooms.

Improving quality and safety of healthcare can be achieved by establishment of a feedback culture, where performance is monitored, feedback is provided and interventions deployed, then the same process is repeated and refined.[27] MPOG data is used to create QI measures, which enables the development of monthly QI feedback reports to participating institutions and individual providers to promote best practices including minimising colloid use in both cardiac and non-cardiac surgery. Those periodic feedback reports have been shown to improve compliance with different anaesthesia QI measures.[28] Our QI team used those reports to assess our baseline performance and how we compare to other institutions before we started the QIP. It also allowed us to engage in proposing an adjustment to the MPOG definition of the FLUID-01-C measure to focus on colloid administration by the anaesthesiologist. Those monthly reports provided near time feedback as our interventions aiming to reduce albumin utilisation went into effect. Our QI team was able to track our performance monthly as the percentage of cases passing the FLUID-01-C measure increased, improving our performance among participating institutions on that measure.

Successful reduction of postoperative albumin utilisation and subsequent cost savings have been reported in ICU patients with no significant difference in outcomes.[29–31] Interventions to achieve that goal varied among institutions and included changing institutional guidelines to restrict albumin use after cardiac surgery,[29 30] removing albumin from routine ICU admission order set,[30 31] surveying providers and answering their questions to address their concerns[31] and providing monthly feedback as well as explicit financial incentives for providers who reduce their albumin utilisation.[29] Our QI study achieved similar results of reducing albumin utilisation and cost, but in the intraoperative setting. We introduced a bundle of both educational and actionable interventions in a staggered manner that included education about appropriate albumin use and indications, email communications that were reinforced with OR teaching, removing albumin from the standard pharmacy intraoperative cardiac medication trays that are dispensed for cardiac surgical cases, dedicating a grand rounds presentation to discussing the QIP and highlighting the previous interventions, and finally continuing our follow-up with provider feedback. Interventions typically start with education of providers, and addressing their concerns, followed by applying a certain degree of restriction to free access to albumin, and finally, providing providers with periodic near real-time feedback on their performance. The choice of intervention was probably not as important as tailoring them to the workflow and culture of each institution and ensuring compliance with the selected interventions.

This QIP is limited by all the inherent limitations to such QI initiatives, where it is not designed to contribute to generalisable knowledge. Our QI team was trying to improve our practice to an established standard of care rather than testing a hypothesis. Additionally, we used MPOG data, which has the inherent limitations to large data repositories that collect data from multiple sites over long periods of time, with heterogeneity of practice, and continual expanding of participating institutions. We mitigated these limitations by analysing a single institution's data over a relatively short period of time. Our core group of cardiac anaesthesiologists at a single academic centre agreed that albumin utilisation should be avoided unless clearly indicated, however, there was variability among providers on the definition of a clear indication for albumin utilisation. It was important to us that a robust feedback tool like the monthly MPOG report on the FLUID-01-C measure should only include albumin administered by anaesthesiologists. Albumin administered by perfusionists was not accounted for, however, our QI team separately discussed the available literature with our perfusionists, who agreed to limit their use of albumin. Additionally, albumin administered postoperatively was outside the scope of this study, given the wide heterogeneity of ICU providers taking care of those patients who can prescribe and administer albumin. Finally, a statistical limitation when implementing multiple staggered interventions, only the first one was used as the time point for the intervention in the segmented regression, since it represents where a change in outcomes of interest may start occurring, and the regression model does not capture individual effects of subsequent interventions.

Our QIP team implemented a few simple and low-cost interventions that managed to decrease the overall use of albumin in patients undergoing cardiac surgery at a single academic medical centre, which translated into considerable cost savings. QIP teams can leverage the near time feedback provided by MPOG quality measures to fine tune their interventions and improve their institutional performance on different MPOG quality metrics.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Duke University IRB# Pro00113460. Consent was waived by the IRB because the study uses deidentified data.

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