Intraoperative factors associated with unplanned return to the operating room after emergent hemorrhage control surgery

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BACKGROUND: Unplanned return to the operating room (uROR) is associated with worse outcomes and increased mortality. Little is known regarding intraoperative factors associated with uROR after emergent surgery in trauma patients. The objective of this study was to identify intraoperative factors associated with uROR after emergent hemorrhage control procedures in bleeding trauma patients.

METHODS: We used anesthetic record of intraoperative management to perform a retrospective study (2017–2022) of bleeding trauma patients who were taken for an emergent hemorrhage control operation.

RESULTS: A total of 225 patients met the inclusion criteria, 46 (20%) had uROR, and 181 (80%) did not. While there was no difference in demographics, mechanism, admission physiology, or time from emergency department to operating room, the uROR patients had a higher Injury Severity Score (30 vs. 25, p = 0.007). While there was no difference in volume of crystalloid infused (3,552 ± 2,279 mL vs. 2,977 ± 2,817 mL, p = 0.20), whole blood (2.2 ± 0.9 vs. 2.0 ± 0.5, p = 0.20), or platelets (11.6 ± 8.6 vs. 9.2 ± 9.0, p = 0.14), the uROR group received more packed red blood cells (11.5 ± 10.6 vs. 7.8 ± 7.5, p = 0.006) and plasma (9.6 ± 8.3 vs. 6.5 ± 6.6, p = 0.01), and more uROR patients received ≥10 U of packed red blood cells (48% vs. 27%, p = 0.006). Damage-control surgery (DCS) was more common in uROR patients (78% vs. 45%, p < 0.0001). After logistic regression, ≥10 U of packed cells in the operating room (4.3 [1.5–12.8], p = 0.009), crystalloid (1.0 [1.0–1.001], p = 0.009), International Normalized Ratio (INR) (7.6 [1.3–45.7], p = 0.03), and DCS (5.7 [1.7–19.1], p = 0.005) were independently associated with uROR.

CONCLUSION: Massive transfusion, crystalloid resuscitation, persistent coagulopathy, and DCS are the most significant risk factors for uROR. During hemorrhage control surgery in bleeding trauma patients who receive ≥10 U of blood, providers must maintain a keen focus on minimizing crystalloid and ongoing balanced resuscitation, particularly during damage-control procedures. (*J Trauma Acute Care Surg.* 2025;98: 64–68. Copyright © 2024 American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCE: Therapeutic/Care Management; Level IV.

KEY WORDS: Coagulopathy; crystalloid resuscitation; damage-control surgery; massive transfusion; unplanned return to the operating room.

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Unplanned return to the operating room (uROR) is defined as a return to the operating room (OR) for an additional procedure because of a complication or unintended outcome related to the primary procedure and serves as a commonly used metric for quality of surgical care.[1–4] Previous studies have established that uROR in adult trauma patients is associated with increased morbidity, mortality, length of stay, and overall hospital charges.[1–6] The most common reasons for uROR include hemorrhage, infection, and technical error.[2,5] Beyond this, the current body of literature describing factors predicting uROR is sparse, highly fragmented among individual surgical subspecialties, and rarely describes specific intraoperative risk factors.[7] To the best of our knowledge, there is no previous literature describing intraoperative factors associated with uROR after emergent surgery for traumatic injuries. We hypothesized that there are specific intraoperative factors, some of which may be addressed at the index operation, which are independently associated with uROR after hemorrhage control procedures in trauma patients.

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PATIENTS AND METHODS

We performed a retrospective study (2017–2022) of trauma patients admitted to our academic, American College of Surgeons-verified, Level 1 trauma center, who were bleeding (defined as massive transfusion protocol [MTP] activated and received at least 3 U of blood) and were taken for an emergent (defined as directly from emergency department [ED] to OR) hemorrhage control operation (laparotomy, thoracotomy, sternotomy, or open vascular procedure). Our institution's MTP protocol consists of 2 U of whole blood, followed by a transition to 1:1:1 component transfusion. Patients who underwent ED thoracotomy or died during the index operation were excluded. Data were obtained from the trauma registry, operative report, and intraoperative anesthetic record. The inclusion criteria were as follows: (1) MTP activated and received at least 3 U of blood and (2) the patient was taken directly from the ED to the OR for a hemorrhage control operation (laparotomy, thoracotomy, sternotomy, or open vascular procedure). The exclusion criteria were as follows: (1) pediatric patients (younger than 18 years), (2) patients currently pregnant, (3) patients who underwent ED thoracotomy, and (4) patients who died during the index operation.

Variables collected included patient demographics, mechanism of injury, Injury Severity Score (ISS), admission physiology, and time from arrival to OR. Intraoperative variables included operation performed, length of operation, intraoperative physiology, crystalloid and blood products (whole blood, packed red blood cells [PRBCs], plasma, platelets) administered, and the need for damage-control surgery (DCS). Damage-control surgery was defined as being specifically described in the operative note from the index operation. Adjuncts to resuscitation collected included the use of bicarbonate, calcium, and vasopressors. Laboratory values collected before and after the index operation included pH, lactate, hemoglobin, and coagulopathy (defined as an INR of ≥1.5). In the patients requiring uROR, indications for such procedure, as well as related intraoperative

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TABLE 1. Unplanned Return to the OR Versus No Unplanned Return to the OR (Whole Sample)

Variable	Ø Unplanned Return to OR (n = 179)	+ Unplanned Return to OR (n = 46)	p
Laboratory values			
pH on arrival	7.20 ± 0.14	7.14 ± 0.20	**0.0148**
Final intraoperative pH	7.29 ± 0.12	7.27 ± 0.13	0.3787
Minimum intraoperative pH	7.18 ± 0.14	7.10 ± 0.19	**0.0035**
Lactate on arrival	5.82 ± 3.42	7.20 ± 4.38	**0.0239**
Final intraoperative lactate	4.69 ± 2.50	6.67 ± 3.73	**0.0002**
Maximum intraoperative lactate	6.11 ± 3.39	7.90 ± 4.19	**0.0029**
Hemoglobin on arrival	12.63 ± 2.00	11.51 ± 2.15	**0.0010**
Hemoglobin at end of case	11.69 ± 1.96	10.95 ± 2.20	**0.0386**
INR on arrival	1.18 ± 0.24	1.25 ± 0.29	0.1289
Postoperative INR	1.21 ± 0.23	1.30 ± 0.42	0.0950

Bold indicates statistical significance.

findings, were also collected. The primary outcome was uROR, while secondary outcomes included mortality, length of stay in the hospital and ICU, ventilator days, and complications (including Myocardial Infarction, cardiac arrest, Deep Vein Thrombosis, Pulmonary Embolism, or any infectious complication).

Data were analyzed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC). While controlling for other variables, logistic regression analysis was performed to determine factors independently associated with uROR. Variables that were adjusted for in our logistic regression were age, ISS, blunt mechanism, minimum intraoperative body temperature, final intraoperative lactate, postoperative INR, PRBCs of ≥10 U, total volume crystalloid (mL) from Emergency Medical Services arrival through index operation end, and DCS. Additionally, we conducted a descriptive analysis of patients requiring uROR to identify the indications for, and intraoperative findings of, the uROR event. Values are reported as mean ± SD, median (interquartile range [quartile 1 to quartile 3]), raw percentages, or adjusted odds ratios with 95% confidence intervals. A p value of <0.05 was considered significant. Our local institutional review board approved this study. The STROBE guideline was used to ensure proper reporting of methods, results, and discussion (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/D895).

RESULTS

A total of 225 patients met our inclusion criteria, 46 (20%) required uROR, while 179 (80%) did not. When comparing uROR to no uROR, there was no difference in age (38 ± 16 vs. 40 ± 16 years, p = 0.48), male sex (85% vs. 80%, p = 0.50), White/non-Hispanic race/ethnicity (33% vs. 38%, p = 0.61), and penetrating mechanism of injury (37% vs. 46%, p = 0.28), but the uROR group had a higher median ISS (30 [25–43] vs. 25 [16–35], p = 0.007). When further stratified by body region, the uROR group had a higher abdominal Abbreviated Injury Scale (3.3 ± 1.5 vs. 2.4 ± 1.8, p = 0.001), but there was no difference in the other body regions including head and neck (1.7 ± 2.0 vs. 1.4 ± 1.9, p = 0.28), chest (2.0 ± 1.6 vs. 2.1 ± 1.6, p = 0.84), pelvis (1.9 ± 1.7 vs. 1.9 ± 1.6, p = 0.94), or extremity injuries (0.78 ± 0.81 vs. 0.89 ± 0.76, p = 41). On admission to the ED, there was no difference in heart rate (113 ± 36 vs. 110 ± 29, p = 0.45), systolic blood pressure (92 ± 36 vs. 93 ± 29, p = 0.90), Glasgow Coma Scale (13 [6–15] vs. 13 [3–15], p = 0.87), or minutes from ED to OR (34 ± 33 vs. 42 ± 42, p = 0.22).

In the OR, uROR patients more often underwent laparotomy (91% vs. 77%, p = 0.03), but there was no difference in other operative procedures including thoracotomy (11% vs. 9%, p = 0.69), sternotomy (0% vs. 4%, p = 0.17), or vascular procedures of the neck (4% vs. 7%, p = 0.56), trunk (15% vs. 13%, p = 0.75), or extremity (13% vs. 24%, p = 0.11). Furthermore, there was no difference in the index operation's length (141 ± 92 vs. 123 ± 76 minutes, p = 0.17). Finally, the uROR group more often underwent a damage-control procedure (78% vs. 45%, p < 0.001).

While there was no difference in volume of crystalloid infused (3,552 ± 2,279 vs. 2,977 ± 2,817 mL, p = 0.20), whole blood (2.2 ± 0.9 vs. 2.0 ± 0.5, p = 0.20), or platelets (11.6 ± 8.6 vs. 9.2 ± 9.0, p = 0.14), the uROR group received more PRBCs (11.5 ± 10.6 vs. 7.8 ± 7.5, p = 0.006) and plasma (9.6 ± 8.3 vs. 6.5 ± 6.6, p = 0.01), and more uROR patients received ≥10 U of PRBCs (48% vs. 27%, p = 0.006). In addition, while there was no difference in the percent of patients who received calcium as an adjunct (96% vs. 88%, p = 0.12), the uROR group received a higher dose of calcium (2.9 ± 3.0 vs. 1.9 ± 1.5, p = 0.002) and more often received bicarbonate (72% vs. 50%, p = 0.008) and vasopressors (28% vs. 13%, p = 0.03). Laboratory values for both groups are shown in Table 1.

When controlling for other clinically significant variables, factors independently associated with uROR included postoperative INR, transfusion of ≥10 U of PRBCs, total crystalloid volume, and the need for DCS (Table 2). While there was no difference in mortality (24% vs. 13%, p = 0.08), the uROR group spent more days in the intensive care unit (ICU) (19 ± 15 vs. 10 ± 9, p < 0.0001), hospital (32 ± 31 vs. 17 ± 15, p < 0.0001), and on the ventilator (13 ± 14 vs. 5 ± 7, p < 0.0001). In addition, the uROR group had more postoperative complications (52% vs. 17%, p < 0.0001).

TABLE 2. Fixed Regression for Unplanned Return to OR (Whole Sample)

Regressor	Odds Ratio (95% CI)	p
Age	1.002 (0.971–1.034)	0.8894
ISS	1.008 (0.965–1.053)	0.7071
Blunt mechanism	1.164 (0.343–3.946)	0.8072
Minimum intraoperative body temperature, °C	0.813 (0.546–1.213)	0.3109
Final intraoperative lactate	1.162 (0.979–1.380)	0.0859
Postoperative INR	9.404 (1.464–60.393)	**0.0182**
pRBCs ≥10 U	4.532 (1.507–13.631)	**0.0072**
Total volume crystalloid from EMS arrival through end of case, mL	1.000 (1.000–1.001)	**0.0059**
DCS	7.282 (2.051–25.852)	**0.0021**

Bold indicates statistical significance.

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When looking at a subgroup of the 117 patients who underwent DCS, factors independently associated with uROR included postoperative INR, transfusion of ≥10 U of PRBCs, and total crystalloid volume (Table 3). While there was no difference in in-hospital mortality (22% vs. 15%, $p = 0.33$), the uROR group spent more days in the ICU (19 ± 15 vs. 11 ± 10, $p = 0.002$), hospital (31 ± 30 vs. 19 ± 17, $p = 0.008$), and on the ventilator (12 ± 13 vs. 7 ± 9, $p = 0.01$). In addition, the uROR group had more postoperative complications (56% vs. 21%, $p = 0.0002$).

On descriptive analysis of patients requiring uROR, several common indications for uROR were identified. Such uROR indications were classified into four main categories: bleeding, compartment syndrome, intra-abdominal sepsis, and wound complications (including surgical site infections and dehiscence). Bleeding was the most common indication for uROR (65%, n = 30), with compartment syndrome (7%, n = 3), intra-abdominal sepsis (20%, n = 9), and wound complications (9%, n = 4) representing less common causes. Next, uROR intraoperative findings were classified into seven main categories: bleeding, ischemic complications, compartment syndrome, wound complications (including surgical site infections and dehiscence), missed injury, negative laparotomy, or other (including anastomotic leak, bile duct leak, and vascular complications). Of these categories, bleeding was similarly the most common uROR intraoperative finding (61%, n = 28). Ischemic complications (7%, n = 3), compartment syndrome (4%, n = 2), wound complications (11%, n = 5), missed injury (4%, n = 2), negative laparotomy (4%, n = 2), and other (9%, n = 4) were all less common uROR intraoperative findings.

DISCUSSION

The purpose of this study was to compare bleeding trauma patients who required uROR with those who did not, in hopes of identifying intraoperative factors associated with uROR. Our study ultimately yielded crucial insight regarding factors associated with uROR in bleeding trauma patients, providing the opportunity for early identification of, and intervention for, high-risk patients. Specifically, during the index operation, patients requiring uROR received more PRBCs, plasma, calcium, bicarbonate, and vasopressors intraoperatively. Furthermore, after controlling for other clinically significant variables, our study identified postoperative INR, transfusion of ≥10 U of PRBCs, total crystalloid volume, and the need for DCS to be independently associated with uROR. These independent associations persisted among a subgroup of DCS patients. The patients with uROR had longer hospitalizations and ICU stays, required more ventilator support, and had more postoperative complications. Ultimately, our results confirmed our hypothesis, as we identified several independent predictors of uROR after hemorrhage control procedures in trauma patients, several of which may be addressed at the index operation.

TABLE 3. Fixed Regression for Unplanned Return to OR (DCS Subset)

Regressor	Odds Ratio (95% CI)	p
Age	1.007 (0.970–1.046)	0.6982
ISS	1.015 (0.963–1.070)	0.5812
Blunt mechanism	0.965 (0.220–4.233)	0.9626
Minimum intraoperative body temperature, °C	0.579 (0.310–1.082)	0.0867
Final intraoperative lactate	1.104 (0.904–1.349)	0.3327
Postoperative INR	26.510 (3.310–304.272)	**0.0085**
pRBCs ≥10 U	7.499 (1.901–29.589)	**0.0040**
Total volume crystalloid from EMS arrival through end of case, mL	1.001 (1.000–1.001)	**0.0043**

Bold indicates statistical significance.

As previously established, the body of literature describing risk factors for uROR is sparse and highly fragmented. Some literature describes intraoperative risk factors among surgical patients in general. For example, one study used anesthesia records of all surgical patients who required uROR and found more uROR in patients with intracranial and intraoral lesions, highest mean arterial pressure of ≥110 mm Hg, highest heart rate of ≥100 beats per minute, anemia, duration of operation of >120 minutes, and arrival from the ICU.[7] Furthermore, some literature describes general, but not intraoperative, risk factors among trauma patients specifically. For example, one study conducted a retrospective analysis of the National Trauma Data Bank and established 27 independent predictors of uROR, the strongest of which being compartment syndrome.[8] However, there is a large gap in the understanding of intraoperative risk factors specifically among bleeding trauma patients.

Our study findings offer promising evidence to fill this gap. In contrast to the aforementioned studies, we established that massive transfusion, crystalloid resuscitation, persistent coagulopathy, and DCS are the most significant risk factors for uROR among our patient population. Considering the known association between massive transfusion in trauma patients and the lethal triad of acidosis, hypothermia, and coagulopathy, this finding is not surprising.[9] Recent literature suggests that rotational thromboelastometry and related technologies may be useful in the early management of acute traumatic coagulopathy, as opposed to traditional scoring systems, which have largely failed to demonstrate an association with patient outcomes.[10,11] Thus, our findings underscore the need for the widespread dissemination of such tools, in the early management (the prehospital, ED, and index operation settings) of bleeding trauma patients.

Next, we evaluated several prehospital variables in patients with uROR. Our results suggest that patients who are more severely injured are at elevated risk for uROR, similar to the results of previous literature.[8] Furthermore, as previously stated, our study established the total volume of crystalloid received from EMS arrival through the end of the index operation to be an independent predictor of uROR. This finding underscores the need for prehospital providers to minimize crystalloid resuscitation in bleeding trauma patients. Unfortunately, prehospital fluid resuscitation remains an evolving topic with vast geographic variation and few standardized, clearly established evidence-based clinical practice guidelines to aid in management.[12] Our study offers favorable evidence in support of early resuscitation with blood products, as opposed to crystalloid.

Next, regarding outcomes, among both the whole patient sample and the DCS subgroup, our study found that there was no significant difference in 24-hour or in-hospital mortality among patients with uROR. This finding differs from previous

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literature, which found increased mortality among patients requiring uROR.[2,5,6] However, our study found that patients in the uROR group spent more days in the hospital, ICU, and on the ventilator, and had more postoperative complications, findings consistent with previous literature.[2,4,6]

Finally, on descriptive analysis of patients requiring uROR, our study identified common indications for, and intraoperative findings of, the uROR event. The most common indication for reoperation was bleeding, representing 65% of the cases. Likewise, the most common uROR intraoperative finding was bleeding, representing 61% of the cases. These results mirror those described by Kao et al.,[5] where 63% of their uROR etiology was secondary to bleeding. Notably, our study differs in that we specifically studied surgical trauma patients versus surgical-all comers. Thus, it is probable that our population had a greater portion of bleeding secondary to coagulopathy. This is supported by the fact that most uROR intraoperative reports documented bleeding secondary to acute coagulopathy versus technical error. Ultimately, our findings suggest that unresolved coagulopathy was the principal driver for uROR.

Limitations

This was a retrospective cohort study and subject to inherent limitations of retrospective research, including but not limited to incomplete or absent data. Furthermore, our data were limited to that obtained from the trauma registry, operative reports, and intraoperative anesthetic records. Thus, we did not collect data from the prehospital setting, using EMS data, nor did we collect data outside of the OR upon hospital admission, while patients were undergoing resuscitation in the surgical ICU between the index operation and unplanned return to the OR. Future studies should expand upon the data set our team used to study additional predictors of uROR in bleeding trauma patients.

CONCLUSION

Massive transfusion, crystalloid resuscitation, persistent coagulopathy, and DCS are the most significant risk factors for uROR. During hemorrhage control surgery in bleeding trauma patients who receive ≥10 U of blood, there should be a keen focus on minimizing crystalloid and ongoing balanced resuscitation, particularly during damage-control procedures.

AUTHORSHIP

K.M.W. and S.E.M. contributed in the literature search. M.W.M., E.B., J.M.B., P.G.R.T., J.J.D., T.C.C., M.T., S.A., M.R., and C.V.R.B. contributed in the study design. K.M.W., E.B., and J.M.B. contributed in the data collection. M.R., S.A. contributed in the data analysis. K.M.W., S.E.M., M.W.M., E.B., J.M.B., P.G.R.T., J.J.D., T.C.C., M.T., S.A., M.R., and C.V.R.B. contributed in the data interpretation. K.M.W. and C.V.R.B. contributed in the writing. K.M.W., M.W.M., E.B., J.M.B., P.G.R.T., J.J.D., T.C.C., J.A., M.T., M.R., S.A., M.R., and C.V.R.B. contributed in the critical revision.

DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/D896).

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