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Clinical Investigation

CLINICAL INVESTIGATION

Intraoperative oliguria predicts acute kidney injury after major abdominal surgery

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Abstract

Background. The threshold of intraoperative urine output below which the risk of acute kidney injury (AKI) increases is unclear. The aim of this retrospective cohort study was to investigate the relationship between intraoperative urine output during major abdominal surgery and the development of postoperative AKI and to identify an optimal threshold for predicting the differential risk of AKI.

Methods. Perioperative data were collected retrospectively on 3560 patients undergoing major abdominal surgery (liver, colorectal, gastric, pancreatic, or oesophageal resection) at Kyoto University Hospital. We evaluated the relationship between intraoperative urine output and the development of postoperative AKI as defined by recent guidelines. Logistic regression analysis was performed to adjust for patient and operative variables, and the minimum *P*-value approach was used to determine the threshold of intraoperative urine output that independently altered the risk of AKI.

Results. The overall incidence of AKI in the study population was 6.3%. Using the minimum *P*-value approach, a threshold of 0.3 ml kg^{-1} h^{-1} was identified, below which there was an increased risk of AKI (adjusted odds ratio, 2.65; 95% confidence interval, 1.77–3.97; $P<0.001$). The addition of oliguria <0.3 ml kg^{-1} h^{-1} to a model with conventional risk factors significantly improved risk stratification for AKI (net reclassification improvement, 0.159; 95% confidence interval, 0.049–0.270; $P=0.005$).

Conclusions. Among patients undergoing major abdominal surgery, intraoperative oliguria <0.3 ml kg^{-1} h^{-1} was significantly associated with increased risk of postoperative AKI.

Key words: acute kidney injury; general surgery; monitoring, intraoperative; oliguria

Oliguria is widely viewed as an early marker of decreased kidney perfusion and impending acute kidney injury (AKI). The use of urine output (UO) to guide fluid therapy is often recommended by textbooks and guidelines[1–3] and is the standard practice in perioperative or critical care settings.[4 5]

Although oliguria is usually defined as a UO <0.5 ml kg^{-1} h^{-1} in medical and surgical practice,[1 2] this threshold of UO is not supported by clinical evidence. The most recent update of the Surviving Sepsis Campaign guidelines does not mention a target value of UO;[3] in contrast, the previous version recommended that initial resuscitation goals should include UO ≥ 0.5 ml kg^{-1} h^{-1}.[6] Although serum creatinine (SCr) roughly represents the glomerular filtration rate,[7] UO is influenced by many factors, including haemodynamics, sympathetic tone, and aldosterone and antidiuretic hormone concentrations. Therefore, thresholds of clinically significant oliguria, indicating renal hypoperfusion or

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Editor's key points

- The risks of excessive fluid administration and the benefits of restrictive fluid therapy in some patient groups are well recognized.
- However, oliguria, traditionally defined as a urine output <0.5 ml kg^{-1} h^{-1}, is considered a risk factor for acute kidney injury (AKI) despite conflicting data.
- This large retrospective study examined different thresholds of urine output associated with risk of AKI after major abdominal surgery.
- Intraoperative urine output <0.3 ml kg^{-1} h^{-1} was independently associated with a significant risk of AKI, but urine outputs of 0.3–0.5 ml kg^{-1} h^{-1} were not.
- These results cast doubt on the risks of perioperative oliguria as conventionally defined.

impending AKI, may vary depending on clinical settings or patient conditions.

Fluid replacement targeting a higher UO tends to lead to increased fluid loading, which may be harmful; recent randomized trials have demonstrated that perioperative fluid overloading markedly increases postoperative morbidity and length of hospital stay.[8–11] Conversely, allowing a lower UO may cause renal hypoperfusion and associated kidney damage. Therefore, identification of the optimal threshold for clinically significant oliguria might help to optimize fluid management. However, to our knowledge, no study has attempted to identify an optimal threshold of intraoperative UO in surgical patients associated with increased risk of postoperative AKI.

The authors hypothesized that there is a threshold of intraoperative UO below which the risk of postoperative AKI increases. The aims of this large-scale retrospective study were as follows: (i) to investigate the relationship between intraoperative UO during major abdominal surgery and the development of postoperative AKI; and (ii) to identify an optimal threshold that predicts the differential risk of AKI.

Methods

Study design, setting, and population

This single-centre retrospective cohort study was conducted in Kyoto University Hospital, which is a teaching hospital in Japan with 1121 beds. The institutional review board approved the study protocol (approval number: R0672, July 26, 2016) and waived the requirement for informed consent.

We included patients aged 18 yr or older who underwent major abdominal surgery under general anaesthesia at Kyoto University Hospital from March 2008 to April 2015 (i.e. from the inception of an electronic database of surgical patients at our centre to the conception of this study). Major abdominal surgery included liver, colorectal, gastric, pancreatic, or oesophageal resection by either laparotomy or a laparoscopic approach. For patients who had more than one surgery meeting the inclusion criteria during the study period, only the index procedure was included. Exclusion criteria were concurrent cardiac or urological procedures and patients with end-stage renal disease (i.e. estimated glomerular filtration rate of <15 ml min^{-1} 1.73 m^{-2}, as determined using a formula validated in Japan,[12] or receipt of haemodialysis). In addition, patients who received diuretics (furosemide, human atrial natriuretic peptide, or mannitol) during surgery were also excluded to eliminate their confounding effects.

Data collection

Data on study participants were collected from the electronic database and the electronic medical record system. To prevent variability in data collection, we collected data according to uniform criteria, especially regarding definitions of the medical conditions. Definitions of variables are listed in Supplementary Table S1. Procedure names recorded in the electronic database were used to identify and group major abdominal surgeries. The type of surgery was categorized into six groups (liver, colorectal, gastric, pancreatic, oesophageal, and complex) and also divided into laparoscopic or non-laparoscopic surgery. 'Complex' means concomitant resection of two or more organs listed above. For each patient, we calculated the average intraoperative UO per hour based on body weight by dividing the total intraoperative UO by the duration of operating room stay and by the measured body weight.

Outcome

The primary outcome was AKI as determined by change in SCr according to the Kidney Disease: Improving Global Outcomes (KDIGO) definition[13] (increase in SCr of $\geq$26.5 μmol litre^{-1} within 48 h or $\geq$1.5 times baseline within 7 days after surgery). The most recent SCr measured before the surgery was used as the baseline value.

Statistical analyses

The analyses of the relationship between intraoperative UO and AKI were planned before data evaluation. We examined the unadjusted relationship between intraoperative UO and the risk of AKI using a cubic spline function to identify any inflection point that could be used to dichotomize intraoperative UO into categories in a clinically meaningful way. If we observed an area of inflation, the optimal threshold for intraoperative UO was determined using the minimum *P*-value approach. This approach evaluated every possible threshold of intraoperative UO at intervals of 0.1 ml kg^{-1} h^{-1} in the multivariable logistic regression model, and the intraoperative UO that demonstrated the smallest statistically significant *P*-value was selected as the optimal threshold to dichotomize intraoperative UO. In the multivariable model, the AKI risk index[14] was used to adjust for the preoperative risk of AKI. This is a previously developed and validated risk index for predicting postoperative AKI in patients undergoing general surgery and includes age, sex, emergency surgery, intraperitoneal surgery, diabetes mellitus, active congestive heart failure, ascites, hypertension, and preoperative renal insufficiency. In addition, type of surgery, intraoperative blood loss (per kilogram body weight), and intraoperative continuous infusion of vasopressors were included in the model to adjust for the type and invasiveness of surgery. The linearity of the association between intraoperative blood loss and the log-odds of AKI was assessed using a cubic spline function and categorized if significant non-linearity ($P<0.05$) was found. Multicollinearity among variables was assessed by the variance inflation factor, with a reference value of 10. Discrimination and calibration of the multivariable model was assessed based on the c-index and the Hosmer–Lemeshow goodness-of-fit test, respectively. We assessed whether the addition of intraoperative UO to the model that included only AKI risk index and