Patient safety is a critical issue in elective total joint replacement surgery. Identifying risk factors that might predict complications and intensive care unit (ICU) admission proves instrumental in reducing morbidity and mortality. The institution’s experience with risk stratification and pre-operative ICU triage has resulted in a reduction in unplanned ICU admissions and post-operative complications after total hip replacement. The application of the prediction tools to total knee replacement has proven less robust so far. This work also reviews areas for future research in patient safety and cost containment.

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variables, as well as post-operative factors associated with those patients admitted unplanned to an ICU from a series of 1259 THR patients. In comparing unplanned ICU admissions with the control group, regression analysis demonstrated that age > 75 years, body mass index > 35 kg/m², creatinine clearance < 60 mL/min, revision surgery, and prior myocardial infarction were independent risk factors for ICU admission. If a patient possessed several risk factors, the risk of unplanned admission to the ICU accordingly rose.

This risk model was then applied in a prospective series of consecutive THR patients. All were assigned to either the ICU or a ward based on these multivariate risk factors. These triage criteria aimed to establish a threshold for planned ICU admission. The primary goal in this pilot study was to influence unplanned admission rates, as well as any major complications. Secondary outcomes included rapid response interventions and any medical or surgical events requiring acute attention. The authors found, with only a modest total increase in the number of planned ICU admissions that our pre-operative assessment resulted in a reduction in both unplanned ICU admissions and major complications in general. The mean number of ICU days for those who were admitted decreased from 2.5 days to 1.7 (2 to 11). This was statistically, as well as clinically significant, both for the institution and model performance characteristics worked in practice.

**Prediction of intensive care need for knee replacement patients**

TKR patients were analysed in a separate retrospective review. This study compared 55 patients who required admission to the ICU post-operatively with 164 patients who did not. The mean age of the ICU patients was 68 years (48 to 90), and the mean age for ward patients was 62 years (35 to 85). Of the intensive care admissions, 60% (33 of 55) were female, and 67% (111 of 164) of ward patients were female.

Univariate analysis was performed to identify factors that might be associated with a statistically significant risk of ICU admission. Revision surgery, creatinine clearance less than 60 mL/min, history of previous myocardial infarction, and American Society of Anesthesiologists (ASA) Class 3 or greater were potential risk factors. The first multivariate model focused on factors that might be known at the time of scheduling a patient for surgery. Pre-operative variables predictive of unplanned ICU admission were age > 75 years, revision surgery, history of obstructive sleep apnea, creatinine clearance less than 60 mL/min, history of previous myocardial infarction and a prior venous thromboembolism. Of these, creatinine clearance less than 60 mL/min and history of previous myocardial infarction were the strongest predictors. The second multivariate model focused on variables known at initial assessment plus the ASA score obtained pre-operatively during the anaesthesia assessment. Out of the variables examined, the strongest individual predictors of ICU admission were previous myocardial infarction and ASA Class 3 or greater.

In planning for a prospective trial for THR, one must consider the performance characteristics of the model. Choosing an appropriate threshold for planned ICU admission in a controlled trial might identify patients with two or more risk factors in addition to an ASA Class > 2. Applying this to the patients in the TKR, one would correctly identify 53 out of the 55 patients admitted to the ICU. However, this triage model would also have identified 85 patients who ultimately did not require intensive care, accounting for a high false positive rate. The strength of the model for TKR patients lies in its negative predictive value (0.93 (0.91 to 0.96)).

**Future study**

This work has inspired ideas for several future projects looking into the issues concerning patient safety, including examination of the costs attributable to ICU intervention. While the authors demonstrated only a modest increase in the total number of ICU admissions in the prospective arm of the THR study, it is unclear without formal cost analysis whether the increased costs of ICU monitoring are offset by the savings associated with reduced morbidity and mortality. Another study could look at the outcomes of patients referred from other institutions. Re-admission rates and longer-term clinical follow-up may offer insight into a lasting benefit, if any, to earlier peri-operative ICU care. Future work may also look at the influence of these safety measures on public and governmental perceptions of orthopaedic care. Of course, more data should allow us to define better the costs involved and resource use associated with tertiary/refererral care of TJR patients; i.e. similar work in other fields of orthopaedic surgery has provided insight into ICU triage.

Yet the triage model established may not be applicable to other institutions due to its relevance to the authors’ institution; and it equally may not be as applicable to those that
perform less TJR surgery. The costs of ICU admission will be significant, and it is reasonable to assume that those patients with the highest medical risk may be most suitable for planned admission and monitoring. An internal analysis of patient characteristics may inform the decision to apply either this or a modified version of the risk model and triage criteria. Multi-centre data and harnessing of large clinical data sets may provide more generalised risk stratification and cost-benefit models.

**Conclusion**

Patient safety is intimately tied to the balance between risk reduction and cost containment. Safety has a direct relationship with the costs of care, reimbursement issues, public policy, patient perceptions and satisfaction with care. Work will need to be continued if patient safety in TJR is to be improved and to reconcile this with cost containment and reduced risk.

According to selected risk factors, pre-operative triage to the ICU affects the reduction in post-operative unplanned ICU admissions as well as major complications, after elective THR. It validates a pre-operative risk stratification model in the authors’ institution, which is a useful decision making tool that facilitates the booking of a THR patient for an ICU admission at the time of pre-operative assessment. However, this area of work is an interdisciplinary effort. The issue of patient safety must bring together different parties across the spectrum of clinical care, and offers an opportunity for synergy.

A study of risk factors that may predict unplanned ICU admission after TKR procedures was not as effective. Further work in larger patient populations, as well as the prospective validation of prediction tools, will allow for the creation of a more robust model for TKR.

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**References**