FREQUENCY, NATURE AND TIMING OF CLINICAL DETERIORATION IN THE EARLY POST-OPERATIVE PERIOD

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ABSTRACT

Aims and objectives: The study aim was to establish the frequency of clinical deterioration in the early post-operative period in patients who have undergone general or orthopaedic surgery.

Background: Worldwide, clinical deterioration is a significant problem in acute care settings. Early recognition and response to clinical deterioration is one of the ten National Safety and Quality Health Service Standards in Australia. However, there is limited understanding of the frequency of clinical deterioration in surgical patients.

Methods: A point prevalence study was conducted from September to October 2014. The records of 100 consecutive in patients admitted for orthopaedic (n = 48) or general surgery (n = 52) to a health service in Melbourne, Australia were audited. The frequency of clinical deterioration episodes was summarised using descriptive statistics.

Results: Baseline characteristics of the two patient groups were equivalent except that orthopaedic patients were older than the general surgery patients (median age 71 (IQR 19) years versus 62 (IQR 17) years). There were 17 medical emergency team calls and 23 calls for urgent clinical review in 28 patients. The main indications for emergency calls were hypotension (26%), fever (19%), hypoxia (15%), tachycardia (13%) and altered blood glucose level (11%). The majority of episodes were managed on the ward, there was one ICU transfer, and no cardiac arrest calls.

Conclusion: One in four patients experienced early post-operative clinical deterioration. Hypotension was the most common trigger for escalation of care highlighting a need to optimise fluid and haemodynamic management of post-operative patients that optimises hydration while preventing fluid overload.

Relevance to Clinical practice: Haemodynamic instability leading to the activation of rapid response systems is very common in the immediate post-operative period. There is the need for locally tailored interventions to optimise fluid management and decrease incidence of further complications.

Keywords: Postoperative care, Surgical nursing, Acute care, Patient safety, Quality & Safety, Emergency, Clinical decision-making.

What does this paper contribute to the wider global clinical community?

- The study shows that, early recognition and response to clinical deterioration decreases the incidence of complications in the immediate postoperative period,
- Hypotension is a common complication leading to the activation of hospital rapid response systems in the immediate postoperative period,
- Early recognition and response to clinical deterioration decreases the need for unplanned ICU admissions.

Introduction

Over the past two decades, the introduction of clinical standards with proactive systems for early recognition and response to clinical deterioration has decreased adverse events, inpatient mortality and unplanned ICU admissions (Alam et al., 2014, Bellomo et al. 2004, Buist, et al. 2002, Ludikhuize, Smoreburg, Rooij & de Jonge 2012). In this study, the frequency of clinical deterioration that fulfilled escalation criteria in the first 72 hours postoperatively amongst patients who have undergone orthopaedic or general surgery was established.

Background

World-wide, there has been considerable interest in achieving early recognition of and response to clinical deterioration in acute care patients (Australian Commission on Safety and Quality in Health Care (ACSQHC), 2008). Previous studies have found that most patients who require unplanned intensive care unit (ICU) admission or cardiac arrest team activation have objective physiological changes as early as 48 hours prior to these events occurring providing an opportunity for earlier intervention (Alam et al. 2014, Amaral et al. 2015, Cioffi et al. 2010, Kyriacos et al. 2011, Smith et al. 2013). Early management of clinical deterioration has also been shown to reduce mortality, morbidity and associated healthcare costs (Bellomo et al. 2004, Chatterjee et al. 2005, Christofidis et al. 2013, Jones et al. 2012, Preece et al. 2012).

Patients undergoing major surgery are at high risk of experiencing acute clinical deterioration with previous studies reporting that five percent will have a clinically important change in physiological signs in the first 24 hours postoperatively (Goldhill 2005, Liddle 2012, McNicol et al. 2007). Preoperative cardiopulmonary function, the type and duration of anaesthesia, the complexity and invasiveness of the surgical intervention all contribute to an increased risk for clinical deterioration postoperatively (Chong et al. 2011, Older & Hall 2004, Scott et al. 2014, Srilata et al. 2014). Early postoperative clinical deterioration remains an ongoing problem with studies showing that patients who have blood pressure or heart rate abnormalities in the post-anaesthesia care unit (PACU) are at a high risk of clinical deterioration once transferred to the surgical ward for postoperative care (Goldhill 2005, Street et al. 2015).

Both orthopaedic and general surgery (that involves opening of the abdominal cavity) are high risk surgical procedures. Opening of the abdominal cavity induces a surgical stress response that results in salt and water retention, vasoconstriction and decreased body temperature all of which contribute to fluid shifts and postoperative haemodynamic instability (Scott et al. 2014). Enhanced recovery after surgery (ERAS) protocols that include: minimising preoperative fasting, intra- and postoperative fluid restriction have been developed to optimise perioperative management and minimise complications. Despite evidence that adherence to ERAS protocols improves patient outcomes (Group EC 2015, Gustafsson et al. 2011), this patient group remains at high risk of early postoperative clinical deterioration Seneviratne et al. 2014). Adult patients undergoing major orthopaedic procedures are typically older with underlying cardiovascular, renal and respiratory conditions placing them at high risk of experiencing perioperative cardiac

events (Chong et al. 2011), delirium (Staus 2011) and respiratory tract infections (Roche et al. 2005).

Rapid Response Systems (RRS) are early warning systems with objective activation criteria that result in expert assessment and management of the deteriorating patient at the point of care (ACSQHC 2008). Medical Emergency Teams (MET) and early clinical review (pre-MET) are examples of RRS used in Australia. MET teams usually consist of an ICU registrar, the treating medical team and critical care nurses. A number of studies have shown that the implementation of RRS such as MET have been beneficial, resulting in earlier recognition and management of clinical deterioration (Casamento et al. 2008, Guinane et al. 2013, Helling et al. 2014, Jones et al. 2012, Mitchell et al. 2010, Odell et al. 2009).

In surgical patients, the introduction of MET has been found to decrease the incidence of serious postoperative complications, unscheduled ICU admissions and mortality (Bellomo et al. 2004, McNeill and Bryden 2013). Bellomo et al (2004) found that following introduction of a MET call team that there was a 58% relative risk reduction for all serious adverse events in postoperative patients; the risk of respiratory failure decreased by 79%, stroke decreased by 78%, severe sepsis 74% and acute renal failure 89%.

Since the introduction of METs in Australia, it has become apparent that patients who receive a MET activation have 25% to 30% inpatient mortality (Buist et al. 2002, Casamento et al. 2008; Jones et al. 2012, Liddle 2012, McNicol et al. 2007). Over the last decade, Australian health services have implemented pre-emptive approaches for earlier escalation of care before physiological changes reach the critical criteria needed for MET activation (ACSQHC 2008). The terminology for these pre-emptive approaches is varied and includes 'urgent clinical review', 'clinical review', 'medical review' 'pre-MET' or Early Warning Systems (EWS) depending on the health service (Bingham et al. 2015). For the purpose of this paper the term pre-MET will be used. While the introduction of MET teams has been shown to have a positive impact on patient outcomes there is less information about the effectiveness of pre-MET calls (Bagshaw et al. 2010, Sprogis et al. 2016).

Previous administrative audits at our institution identified that adult patients undergoing major general and orthopaedic surgery were the two surgical groups with the highest incidence of RRS. The purpose of this study was to establish the frequency, nature and timing of these

events, so that protocols and care pathways could be developed to provide optimal care for these patients.

Aims. The aim of the study was to establish the frequency of clinical deterioration in the early post-operative period in patients who underwent general or orthopaedic surgery. The specific research questions were:

- i) What is the frequency, nature and timing of clinical deterioration that fulfils pre-MET or MET call criteria in the first 72 hours postoperatively?
- ii) Are there clinically important differences between the types and severity of clinical deterioration episodes between the general and orthopaedic surgery groups?
- iii) What is the frequency of clinical deterioration episodes that fulfil hospital escalation criteria in daytime hours (0800-1959 hrs) versus overnight (2000-0759 hrs)?

For the purposes of this study, postoperative clinical deterioration was defined as physiological changes that fulfilled hospital escalation of care criteria (Table 1).

Methods

Design. A descriptive exploratory design was used and study data were collected using clinical audit.

Setting. The study was conducted at a 300 bed hospital within a metropolitan health service in Melbourne, Australia. An average of 112 orthopaedic and 179 general surgical procedures are undertaken each month at the study site.

At the time of the study, there was a three level system in place for escalation of care for clinical deterioration (Table 1). Code Blue was the cardiac arrest emergency code and was activated for cardiopulmonary arrest. The Code Blue team included a consultant intensivist or emergency physician, ICU registrar, admitting officer, personal service assistant, security personnel, medical staff from patient's home team and an ICU or ED nurse consultant. The MET was activated for patients whose vital signs fulfilled predetermined criteria that were highlighted in purple on the organisation's nursing observation and response charts or for clinician concern. The MET response is a team comprising medical staff from the patient's home team, ICU liaison nurse and ICU Registrar who are required to attend the ward within five minutes of the call being activated.

Pre-MET was activated for patients whose vital signs fulfilled predetermined criteria that were highlighted in yellow on the organisation's nursing observation chart, for issues such as

chest pain, abnormal investigation results or changes in behaviour. When a pre-MET call is made, the intern from the patient's home team is required to respond within 15 minutes and if this does not occur, the pre-MET call is escalated to the home team registrar in the next 15 minutes. If these two steps are unsuccessful within 30 minutes of making a pre-MET call, then care is escalated to a MET call.

Sample. A total of 100 consecutive postoperative patients' medical records were audited (Figure 1). Patients included in the audit were above 50 years of age and had undergone major general or orthopaedic surgery at the study site in the two-month period from the 2nd September 2014 to the 31st October 2014. Patients were identified using the operating theatre lists and patients were followed up on the wards for the first three postoperative days.

Based on previous studies, the prevalence of major postoperative complications in older adults undergoing major surgery is 15 to 20% (Bellomo et al. 2003) and local data from the study site showed that 20% of patients fulfilled MET Call criteria within 24 hours of undergoing general surgery (Seneviratne et al. 2014). Based on these previous studies we anticipated that approximately 20% of patients would experience a clinically significant deterioration that required a MET or pre-MET activation in the first 72 hours post-operatively. This was an exploratory study and an event rate of more than 20 patients requiring either a MET or a pre-MET call activated in the first 72 hours postoperatively was deemed sufficient to describe the frequency, nature and timing of postoperative deterioration episodes.

The age inclusion criterion was chosen as older adults and patients who had undergone major invasive surgery are the highest risk group for postoperative complications (Beloosesky et al. 2003). Day procedure cases for either orthopaedic or general surgery were excluded because these patients were not admitted to the inpatient wards and follow-up data were not available as they were discharged the same day as their surgery. Orthopaedic surgery patients included individuals undergoing total hip, knee and other joint replacements, and traumatic fractures that required internal or external fixation. Major general surgical procedures included anterior resection for bowel cancer, cholecystectomy (both laparoscopic and open), pancreatic surgery, surgery for gastric cancer and other general surgical procedures that required an anesthetic time greater than one hour.

Data collection. In the absence of existing tools suitable for use in this study, a data collection tool was developed by the researchers specifically for this study. The parameters

measured were physiological signs and other clinical observations that are included in the study site's escalation of care protocols for clinical deterioration. In addition, data were collected on the proportion of clinical deterioration episodes that required escalation of care within daytime hours (0800-1959 hours) versus overnight (2000- 0759 hours). The study data were collected from the documented time the patient returned to ward from the ward observation charts, fluid balance charts, medication charts, clinical pathways, wound charts and operating room and PACU observation charts.

Ethical considerations. The study was approved by the Human Research and Ethics Committees at the study site (LR 37_2014) and Deakin University (DUREC 2014_167).

Data analysis. Study data were analysed using SPSS Version 22.0. Descriptive statistics were used to summarise the data. As the data were not normally distributed (Kolmogorov–Smirnov test), medians and interquartile ranges (IQR) are presented. The clinical audit data were analysed using descriptive statistics, continuous variables were summarised as mean, median and range and categorical variables was summarised as frequencies and percentages. Differences in age, and duration of anaesthesia between the general surgery and orthopaedic patients were analysed using Mann-Whitney test as the underlying distribution of data for these variables was right skewed. Chi-square tests were used to compare differences in categorical variables between the general surgery and orthopaedic surgery groups (Kurichi & Sonnad 2006). To determine whether individual patients were more likely to have an RRS call for haemodynamic instability in the first 24 hours, McNemar's Chi-square tests for paired data was used to compare the overall difference the proportion of RRS calls for haemodynamic instability that occurred in the first 24 hours compared to RRS calls 25 to 72 hours postoperatively. Multivariate logistic regression was used to compare the odds of RRS call activation according to surgery type; after adjusting for age $< / \geq 80$ years, emergency versus elective surgery and duration of anaesthesia. The dependent variable in the model was defined as activation of at least one RRS call in the first 72 hours postoperatively, independent variables were considered significant if the Odds Ratio was $> / < 1$, the 95% confidence interval did not include 1 and the p value was < 0.05 .

Validity and reliability. Validity can be measured by establishing the similarity between what we are measuring and to what we intend to measure (Roberts et al. 2006). The data collection tool and detailed data dictionary were developed and piloted by the research team and to ensure clarity of the data elements and definitions. This process confirmed that the tool had

sufficient face and content validity to answer the research questions adequately. Reliability is the measure of the ability of a tool to produce similar results in different circumstances without alteration to the measuring tool (Roberts et al. 2006). To ensure inter-rater-reliability of data collection, all of the patients' clinical records were audited by two researchers (SMI and AH) using the data dictionary to ensure consistency and reproducibility in the auditing process.

RESULTS

A total of 48 orthopaedic surgery patients and 52 general surgery patients were included in the study. Participant characteristics are summarised in Table 2. The orthopaedic surgery patients were slightly older than the patients having general surgery (median age 71 (IQR 19) years versus 62 (IQR 17) years, $z = 3.774$, $p < .001$). Approximately 60% of patients in both groups were elective admissions. In the orthopaedic surgery patients, the elective admissions were for joint replacements; 14 patients had total knee replacements and 15 patients had total hip replacements. There were 19 patients who were emergency admissions for management of hip fracture. The general surgical group was more heterogeneous; 35 patients had laparoscopic surgery and of these 27 were admitted for laparoscopic cholecystectomy. Seventeen patients had open abdominal surgery of these, 13 patients underwent surgery for management of gastrointestinal cancers and 4 patients had surgery for other health conditions.

The number of patients audited at each time point during the 72-hour follow-up period varied: some patients had elective postoperative ICU admissions and other patients were discharged home early. The number of patients included in each follow-up time interval is summarised in Figure 1. The general surgical group had a higher number of elective ICU admissions in the immediate postoperative period than the orthopaedic group (19% vs 2%, $\chi^2(1) = 7.50$ $p = .006$), (Table 2).

Frequency, nature and timing of post-operative clinical deterioration

Twenty-eight patients had a pre-MET or MET call over the first three days post-operatively, five patients had more than one pre-MET call and three patients had more than one MET call during the study period. Overall, there were 47 documented changes in physiological signs that fulfilled pre-MET or MET call criteria and 40 of these events resulted in an actual call (Table 3). There was a total of 23 pre-METs activated and 17 MET calls activated in the first 72 hours postoperatively.

In the first four hours, there were four documented physiological changes that fulfilled MET or pre-MET criteria: one activation was for bradycardia, two were for hypotension and one activation was for clinician concern. The highest number of MET or pre-MET calls occurred between 5 and 24 hours post-operatively, including eight calls for hypotension, three calls for heart rate abnormalities and four calls for febrile illness. The proportion of patients who had RRS calls for haemodynamic instability was 18 (20%) of the 89 patients on the ward in the first 24 hours and 7 (9%) of 79 patients on the ward between 25 and 72 hours postoperatively. However, individual patients were not more likely to have RRS calls made for haemodynamic instability in the first 24 hours compared to 25 to 72 hours postoperatively, McNemar's χ^2 test for paired data $\chi^2(1) = 3.56, p = .06$. Hypoxaemia became a more common reason for RRS calls between 25 to 72 hours postoperatively (Table 3).

The majority of MET and pre-MET calls were activated by the bedside nurse. There was one occasion in which the family prompted the nurse about a deteriorating patient and one when a doctor activated the MET call in conjunction with the nurses. The lowest number of RRS calls occurred in the first four hours post-operatively (Table 3). However, the activation of pre-MET calls increased across the time periods examined with the highest number of pre-MET calls ($n = 14/23, 61\%$) occurring between 25 and 72 hours and the highest number of MET calls ($n = 12/17, 71\%$) occurring between 5 and 24 hours.

Clinical deterioration in abdominal versus orthopaedic surgery patients

In total, 28% ($n=28$) participants had at least one escalation of care for deterioration: 19 (19%) were orthopaedic patients and 9 (9%) were general surgery patients. The orthopaedic surgery patients had a higher incidence of deterioration fulfilling pre-MET or MET calls in the first three days post-operatively than general surgery patients and there were more pre-MET calls than MET calls activated in both groups.

In the first 24 postoperative hours, there were six physiological changes in the general surgery patients (one febrile illness, two bradycardia, two tachycardia, one hypotension) resulting in two pre-MET and two MET calls (Table 4). During the same period there were seventeen physiological changes in the orthopaedic surgery patients (three febrile illness, one bradycardia, three tachycardia, nine hypotension, one blood glucose abnormality) resulting in 5 pre-MET calls and 12 MET calls. The most common physiological changes in the first 24 hours

in both groups were abnormal heart rates and hypotension, however hypotension was more common in the orthopaedic patients.

In the 25 to 72-hour period, respiratory issues (hypoxaemia and tachypnoea) that were not present in the first 24 hours became more common in both groups. Between 5 and 24 hours the orthopaedic patients at risk had more episodes of hypotension than the general surgical patients (15% (n = 7) versus 2% (n = 1), $\chi^2(1) = 4.24$, $p = .04$). Between 25 and 72 hours 11% (n = 5) of orthopaedic patients and 12% (n = 4) of general surgical patients had abnormal respiratory signs ($\chi^2(1) = 0.02$, $p > .05$). It is important to note that between 24 and 72 hours, three orthopaedic surgery patients and 18 abdominal surgery patients were discharged from hospital and were therefore not included in the denominator for this time-point.

Logistic regression showed that patients who had undergone orthopaedic surgery had a 3-fold increase in the odds of RRS call in the first 72 hours postoperatively (OR 3.11, 95% CI. 1.18 to 8.18, $p = .022$) after adjusting for age ≥ 80 years, emergency versus elective surgery, and duration of anaesthesia (Table 5).

Clinical deterioration during hours and overnight.

When the timing of pre-MET or MET calls was examined, 17 (58 %) pre-MET or MET calls occurred in hours (0800-1959 hours) and 23 (42%) of pre-MET or MET calls occurred overnight (2000-0759 hours), (Figure 2). In the general surgery group 7 (58%) escalations of care occurred overnight and 5(42%) escalations of care occurred during daytime hours. In the orthopaedic surgery group 16 (57%) escalations of care occurred overnight and 12 (43%) escalations of care occurred during the day. Seventy percent (n = 16) of pre-MET activations occurred overnight compared to 30% (n = 7) during the day. In contrast 7 (41%) of the MET activations occurred overnight compared to 10 (59%) during daytime hours.

DISCUSSION

This prospective study of patients who had undergone major orthopaedic and general surgery, found that 28% percent of patients had at least one episode of clinical deterioration that reached MET or pre-MET criteria in the first three days postoperatively. The majority of these events resulted in ward nurses activating the RRS in place at the study site.

A previous study found that among surgical patients 27% of MET call activations were for patients who had undergone general or orthopaedic surgery (Bellomo et al. 2003). Hypoxaemia, changes in respiratory rate, hypotension, changes in heart rate, changes in

conscious state and decreased urine output were the most common MET call triggers (Bellomo et al. 2003). The number of escalations of care in our study was similar however we had a lower rate of MET calls that may reflect the introduction of the pre-MET system at our centre. Overall the majority of escalation events were managed on the ward and in our study there were no Code Blues calls or deaths reported during the first 72 hours postoperatively. These findings indicate that the introduction of a two-tiered escalation system may result in care being escalated earlier, and that this may potentially decrease the number of events that occur in which patients require critical care admission (Bingham et al. 2015; Mitchell et al. 2010).

During the first 24 hours following return to the ward, hemodynamic instability (specifically hypotension) was the most common reason for escalation of care. In the 25 to 72 hour postoperative period in addition to escalation of care for haemodynamic instability, the number of calls for abnormal respiratory signs (tachypnoea and hypoxia) and raised temperature also increased. These findings are similar to a previous study that identified hypotension and respiratory distress as common postoperative complications leading to the activation of MET calls (Quach et al. 2008).

There was a higher incidence of clinical deterioration in the first 24 hours postoperatively as compared to day two to day three. Postoperative hypotension was the predominant reason for rapid response activation and this was more common in the orthopaedic surgery group when compared to general surgery patients. This finding is similar to an American study, which found that more than 75% of RRS activations in postoperative patients occurred within the first 24 hours on the ward and that the most common reason for RRS activation was haemodynamic instability (Weingarten et al. 2012).

There was a higher incidence of clinical deterioration that fulfilled MET or pre-MET escalation criteria in the orthopaedic patients when compared to general surgery patients, however there were important differences in the models of care provided to each patient group. Most patients who had an elective ICU admission had undergone major open abdominal surgery and were considered to be too unwell to return to ward postoperatively. Therefore, the majority of the highest risk patients in the general surgery group were managed in ICU for the first 24 hours postoperatively meaning that they would not require RRS activation for deterioration. In contrast, the average anaesthetic time for the orthopaedic group was shorter and most orthopaedic surgery patients returned directly to the ward postoperatively.

In the orthopaedic surgery group the majority of patients with hypotension were managed with blood transfusions secondary to anaemia from intraoperative blood loss. In our study we found that, the majority of hypotensive episodes occurred within the first 24 hours and that the nurses believed that a precipitating factor was inadequate hydration both pre and intraoperatively (Mohammediddrisu, Considine & Hutchinson 2018). This finding is similar to that of a previous study of older orthopaedic patients that reported that the consequences of inadequate perioperative fluid management took up to 48 hours to resolve postoperatively (Mercer et al. 2014).

Studies have shown that unplanned hospital admission, increasing age and gastrointestinal disease are significant risk factors for postoperative complications in surgical patients (Austin Health Post-Operative Surveillance Team 2010, Jones et al. 2007, Story et al. 2009, Story et al. 2010). In our study, 61% of patients included in this audit were emergency admissions. Most of the orthopaedic group were older than the general surgery group with multiple co-morbidities placing them at higher risk of postoperative complications. It was difficult to evaluate patients' hydration status based on the information recorded in the medical record, therefore it is not possible to determine whether under-hydration contributed to the hypotensive episodes that occurred in the general surgical group (Mythen et al. 2012). Further research is needed to confirm or refute this possibility.

There were more episodes of clinical deterioration that fulfilled escalation criteria overnight than during daytime hours although this was not statistically significant. This finding resembles previous studies of MET calls that showed that there was higher incidence of MET calls between 1600 to 2400 hours than during the day (Bellomo et al. 2003). In our study, clinical deterioration typically occurred 7 to 24 hours after returning postoperatively to the ward. As the majority of patients return to the wards from lunch time until midnight this is likely to be a contributing factor to the increased incidence of clinical deterioration in the evening and overnight compared to daytime.

Strengths and limitations

One of the strengths of this study was the detailed audit of all the patients' observation charts for the first 72 hours postoperatively, confirming that all changes in vital signs that fulfilled escalation criteria were escalated to the RRS team. In contrast to previous studies, the overwhelming majority of documented deterioration episodes were escalated appropriately. This

finding indicates that initiatives to improve the recognition and response to clinical deterioration are being translated into practice (Guinane et al. 2013, Ludikhuize et al. 2012, Quach et al. 2008).

There are a number of limitations that should be considered when interpreting the study findings. First, this was a single site study therefore the generalisability of results to other centres may be limited. Second, it was beyond the scope of this study to draw any conclusions about whether the RRS improved the outcomes of postoperative patients. Third, the study relied on audit data so it is possible there were gaps in the documentation where deterioration episodes may have occurred but not been documented. Finally, the higher proportion of orthopaedic patients who experienced a clinical deterioration requiring RRS activation may have been influenced by a number of general surgical patients being admitted to ICU for the first 24 hours postoperatively.

CONCLUSION

The results of the study showed that one in four postoperative patients experienced clinical deterioration and that hypotension was the most common reason for escalation of care. The time of day did not have a significant impact on the number of RRS calls activated, however time from transfer to the ward postoperatively was associated with both the number of RRS calls activated and the reason for activation. Importantly the highest incidence of RRS calls occurred between 5 and 72 hours after return from the ward and the most common reason for these calls was haemodynamic instability. The high frequency of hypotension in the first 24 hours postoperatively highlights a need to optimise fluid and haemodynamic management of surgical patients that balance preventing fluid overload versus maintenance of adequate hydration in the early post-operative period.

Relevance for clinical practice. The prevalence of haemodynamic instability leading to the activation of MET/pre-MET is very common in the immediate post-operative period. There is the need for locally tailored interventions to optimise fluid management and decrease incidence of further complications. As hypotension was the most common reason for escalation of care, a better understanding of pre, intra and postoperative fluid and haemodynamic management of is needed to optimise hydration while preventing fluid overload.

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Table 1: Clinical deterioration escalation criteria

A Code Blue Criteria:

- Cardiorespiratory arrest

MET call Criteria:

- Respiratory Rate (RR) $< 10 \geq 30$ breath/minute
- Difficulty Breathing
- Heart rate (HR) < 40 or $\geq$ beats/minute
- HR ≥ 120 beats/minute in first 4 hours post operatively
- Systolic blood-pressure (BP) < 90 mmHg
- Seizure
- Registered Nurse (RN) worried about the patient
- Conscious state: Alert/Voice/ Pain/ Unresponsive (AVPU) scale.
- Oxygen Saturation (SpO₂) $< 90\%$ in resting state with oxygen flow rate > 4 L/min

Pre-Met Call Criteria:

- Chest pain
 - Blood Glucose (BGL) $< 3.5 > 20$ mmols
 - RR 25-29 breaths/minute
 - Systolic BP ≥ 200 mmHg
 - HR < 50 or ≥ 120 beats/minute
 - Urine output < 20 ml/hour for four consecutive hours
 - Temp ≤ 35.4 or ≥ 38 degrees
 - AVPU Scale - response to voice
 - Seriously abnormal investigations
 - New onset Agitation/Confusion
-

Table 2: Participant Characteristics

Total	General	Orthopaedic	P value
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	(N = 100) n (%)	surgery (n = 52) n (%)	surgery (n = 48) n (%)	
Gender				
Female	61 (61)	29 (55.8)	32 (66.7)	.264
Male	39 (39)	23 (44.2)	16 (33.3)	
Age (Years) Median (IQR)				
Range (Years)	50-94	50 - 86	53- 94	< .001
Surgery				
Elective	61 (61)	32 (62)	29 (60)	.909
Emergency	39 (39)	20 (38)	19 (40)	
Indication for surgery				
Benign	87 (87%)	39 (75%)	48 (100)	< .001
Malignant	13 (13%)	13 (25%)	0	
Surgical Approach				
Minimally invasive	35 (35%)	35 (77%)	0	< .001
Open	65 (65%)	17 (33%)	48 (100)	
Duration of anaesthesia (hours)				
Mean (SD)	2.6 (1.8)	3.0 (2.2)	2.2 (0.9)	.474
Range (hours)	1-12	1.05 -12	1- 5.3	
Postoperative destination				
General ward	89 (89)	42 (81)	47 (98)	.006
ICU	11 (11)	10 (19)	1 (2)	
Clinical pathway used				
Yes	32 (32)	10 (19)	22 (46)	< .001
No	68 (68)	42 (81)	26 (54)	
Drain Tube in-situ				
	28 (28)	21 (42)	7 (14.9)	.004
PCA or epidural analgesia in use	38 (38)	15 (29)	23 (48)	.030

*Categorical variables are summaries as frequencies and percentages, differences compared with chi-square tests and, continuous variables were summarised as mean standard deviation and range and differences compared using unpaired T-tests.

Table 3: Physiological parameters that fulfilled escalation criteria over the first three days post-operatively

0-4 hrs	5-24 hrs	25-72 hrs	Total
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	n (%)	n (%)	n (%)	n (%)
Temperature $\geq 38^{\circ}\text{C}$	0	4 (8.5)	5 (10.6)	9 (19)
Tachycardia >120 beats per minute	0	2 (4.2)	4 (8.5)	6 (12.7)
Bradycardia <50 beats per minute	1 (2.1)	1 (2.1)	0	2 (4.2)
Hypotension: systolic blood pressure < 90 mmHg	2 (4.2)	8 (17)	2 (4.2)	12 (25.5)
Tachypnoea RR >25 breaths per minute	0	0	2 (4.2)	2 (4.2)
Hypoxaemia (SpO ₂ $<90\%$)	0	1 (2.1)	6 (12.8)	7 (14.8)
Decreased conscious state	0	3 (6.4)	0	3 (6.3)
Blood Glucose ≤ 3.5 or $\geq 20\text{mmol/L}$	0	1 (2.1)	4 (8.5)	5 (10.6)
Clinician concern	1 (2.1)	0	0	1 (2.1)
Total	4 (8.5)	20 (42.5)	23 (48.9)	47 (100.0)

Table 4: Physiological changes that fulfilled escalation criteria post-operatively in general versus orthopaedic surgery patients

Time	0-4 hours		5-24 hours		25-72 hours	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Physiological change	General surgery n=42	Orthopaedic surgery n=47	General surgery n=42	Orthopaedic surgery n=47	General surgery n=34	Orthopaedic surgery n=45
Febrile	0 (0.0)	0 (0.0)	1 (2.1)	3 (6.4)	0 (0.0)	5 (11.1)
Bradycardia	1 (2.4)	0 (0.0)	1 (2.1)	1 (2.1)	0 (0.0)	1 (2.2)
Tachycardia	1 (2.4)	2 (4.3)	1 (2.1)	1 (2.1)	3 (8.8)	1 (2.2)
Hypotension	0 (0.0)	2 (4.3)	1 (2.1)	7 (14.9)	1 (2.9)	1 (2.2)

Tachypnoea	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.9)	0 (0.0)
Hypoxia	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.9)	5 (11.1)
Blood Glucose	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.1)	0 (0.0)	4 (6.4)
Total	2	4	4	12	8	17

Table 5: Logistic regression model – Factors associated with RRS calls in the first 72 hours postoperatively

	Odds Ratio	Std. Err.	z	P value	95% Conf. Interval
Orthopaedic vs General Surgery	3.11	1.54	2.30	.022	1.18 to 8.18
Age ≥ 80 years	1.66	.96	0.87	.384	.53 to 5.15
Emergency vs Elective Surgery	1.65	.81	1.01	.311	.63 to 4.30
Duration of Anaesthesia (hours)	1.02	.16	0.12	.906	.75 to 1.38
Constant	0.94	0.89	-2.47	.014	.01 to .61
Model Fit					
Log likelihood Ratio = -55.18	Pseudo R ² = 0.078

Figure 1 Flow Diagram of patients included in the audit

Figure 2: Frequency of pre-MET/MET calls daytime versus overnight

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