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Original research

The introduction of an acute physiological support service for surgical patients is an effective error reduction strategy

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ABSTRACT

Introduction: Acute surgical patients are particularly vulnerable to human error. The Acute Physiological Support Team (APST) was created with the twin objectives of identifying high-risk acute surgical patients in the general wards and reducing both the incidence of error and impact of error on these patients. A number of error taxonomies were used to understand the causes of human error and a simple risk stratification system was adopted to identify patients who are particularly at risk of error.

Results: During the period November 2012–January 2013 a total of 101 surgical patients were cared for by the APST at Edendale Hospital. The average age was forty years. There were 36 females and 65 males. There were 66 general surgical patients and 35 trauma patients. Fifty-six patients were referred on the day of their admission. The average length of stay in the APST was four days. Eleven patients were haemo-dynamically unstable on presentation and twelve were clinically septic. The reasons for referral were sepsis,[4] respiratory distress,[3] acute kidney injury AKI (38), post-operative monitoring (39), pancreatitis,[3] ICU down-referral,[7] hypoxia,[5] low GCS,[1] coagulopathy.[1] The mortality rate was 13%. A total of thirty-six patients experienced 56 errors. A total of 143 interventions were initiated by the APST. These included institution or adjustment of intravenous fluids (101), blood transfusion,[12] antibiotics,[9] the management of neutropenic sepsis,[1] central line insertion,[3] optimization of oxygen therapy,[7] correction of electrolyte abnormality,[8] correction of coagulopathy.[2]

Conclusion: Our intervention combined current taxonomies of error with a simple risk stratification system and is a variant of the defence in depth strategy of error reduction. We effectively identified and corrected a significant number of human errors in high-risk acute surgical patients. This audit has helped understand the common sources of error in the general surgical wards and will inform on-going error reduction initiatives.

Article focus

- The peri-operative management of the high risk non cardiac general surgical patient
- Developing a team to manage the acute physiological derangements of acute surgical patients
- Developing an error reduction strategy

Key messages

- Defense in depth strategies may detect error
- There are common patterns of error encountered in the non operative care of acute surgical patients
- Fluid and drug errors are the most common problem

Strengths and limitations of this study' section.

- This is a single institution study and may not be directly applicable elsewhere
- Pragmatic study that identifies common sources of error in acute care.

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1. Introduction

High-risk operations such as cardiac procedures, solid organ transplantation and major oncological resections are centralized in well resourced centers with highly developed systems of care and are generally performed with acceptable morbidity rates and very low mortality rates.[1,2] High-risk non-cardiac general and acute care surgery on the other hand is undertaken in a diverse number of hospitals with variable levels of expertise and resources.[2–8] In the United Kingdom approximately 170,000 patients undergo high-risk, non-cardiac surgery each year and sixty per cent experience significant morbidity and fifteen percent die.[2] There is also an increased awareness that human error contributes significantly to these high levels of surgical morbidity and mortality and there is considerable interest in strategies that try and reduce the incidence and limit the impact of human error on health care.[2–8] Several modern taxonomies of error have been developed to assist with the understanding of the cause of these errors.[3,9,10] Any interventions intended to reduce human error associated morbidity and mortality amongst acute surgical patients, must accurately quantify surgical risk and ensure that the level of risk is commensurate with the appropriateness of the staff caring for the patient and the resources available. To facilitate this the Royal College of Surgeons has defined four levels of care for surgical patients depending on the assessed risk and these are summarized in Table 1.[2]

Edendale Hospital is a regional hospital in the South African city of Pietermaritzburg in the Province of Kwa-Zulu Natal. It drains patients from the peri-urban settlements around the city and from the four deep rural hospitals of Sisonke district. There are ten Intensive Care Unit (ICU) beds five high dependency (HDU) beds in the Pietermaritzburg complex. These units generally run at a hundred percent occupancy and have extremely high patient turnover. For example in 2012 a total of 333 trauma patients were admitted to ICU/HDU in Pietermaritzburg. This is in addition to a significant volume of patients with obstetrical and medical emergencies who also require ICU/HDU care. Surgical patients who are not admitted to the ICU or HDU for whatever reason remain under the care of the surgery department. We have run quality improvement programs at Edendale Hospital for the last five years. These programs arose out of a number of audits of the quality of care at our institution, which identified a number of deficits.[11,12] These deficits included sub-optimal documentation and poor communication leading to preventable errors and morbidity and even mortality.[11,12] In one of these audits a random sample of twenty-five referral letters for patients with Traumatic Brain Injury (TBI) was selected for review. The history was recorded in all the referral letters reviewed, the GCS in 88%, a management plan in 75%, associated localizing signs in 50%, and the condition of the pupils in 13%. In none of the referrals was an assessment of the integrity of the cervical spine recorded. A random sample of 28 inpatient records of patients with TBI was also selected for review. In 57% of cases the reason for admission was not recorded, in 42% a skull radiograph was omitted despite being indicated, and in 15% a computed tomography (CT) scan was omitted despite the case meeting our criteria for this investigation. In the management plans of this group there were no recorded orders for supplemental oxygen and intravenous (IV) fluids. Clear instructions to perform neurological observations were omitted in all cases. In the observation charts of this group the GCS was recorded in 92%, the state of the pupils was recorded in 71%, pulse rate and blood pressure were documented in 70%, oxygen saturation was only recorded in 42%, and neither blood glucose readings nor core body temperature were ever recorded.[11] Another audit from our institution revealed that the routine monitoring of acute trauma patients was inconsistent and incomplete and varied dramatically across geographical locations within the same hospital.[12]

Table 1
Classification of levels of care according to the Royal College of Surgeons of England. (2).

Proposed levels of care (2)	
0 Ward	Basic observations
1: Enhanced ward	At risk of deterioration, more frequent observations, basic resuscitation
2: High dependency	Needs detailed observation, intervention or single organ support
3: Intensive care	Multiple organ support requiring complex interventions

In response to these audits an Acute Physiological Support Team (APST) was established with the twin objectives of identifying high-risk acute surgical patients who were not admitted to ICU/HDU and reducing the incidence and limiting the impact of human error on these patients. The concept of the APST was based on Reasons "Swiss Cheese" model of human error.[9] In this model error is the arrow that has to penetrate multiple layers of defence to strike the patient. However each layer of defence is full of holes, like a piece of Swiss Cheese. If all the holes align then the error can travel in a straight line and hit the patient. Strengthening the multiple layers of defence is known as defence in depth strategy. The APST consisted of a medical officer and an intern under the supervision of a single dedicated senior specialist surgeon. Although there was close liaison with the nursing staff, we were unable to keep a dedicated nursing team and during the period of the study there was considerable turn over of nursing staff. The parent surgical team would formally request that the APST care for the patient. In effect this meant that all patients were seen several times a day by different teams. These included the parent team, the ICU/HDU team and the APST. Each team can be considered as a layer of defence between the error and the patient. The APST had fifteen male beds and ten female beds. Each bed was equipped with non-invasive monitoring equipment as well as oxygen points and infusion pumps. We were not able to provide advanced respiratory support such as CPAP, or inotropic support. The APST developed a monthly structured morbidity and mortality meeting as a feedback or closed loop system. Each month the statistics for the team were presented at the morbidity and mortality meeting. The meeting commenced with an overview of the role of the APST and then a brief discussion on modern concepts of error theory. Two index cases of error were selected out and discussed in detail using a published taxonomy of error.

2. Methodology

All patients who were classified as level II or higher according to the Royal College of Surgeons levels of care and were not admitted to ICU or HDU for whatever reason were referred to the APST. A prospective data-base was established to document each patient referred to the APST. Routine demographic data was recorded as well as data concerning the clinical course. The APST collated all errors detected by the team and the number of interventions to address these errors initiated by the APST. Error was classified according to type or the process that failed, and cause of error. Types of errors were classified as drug related, fluid related, indwelling device related, management decision related and failure to review investigations. Modern taxonomies of error were used to understand the cause of each error. Errors of omission involved the failure to perform an indicated intervention whereas errors of commission involved the inappropriate application of an intervention. Errors of planning involved the incorrect management plan and errors of execution describe an appropriate management plan, which goes awry.

3. Results

During the period October 2012–January 2013 a total of 101 patients were cared for by the APST at Edendale Hospital. The average age was forty years. There were 36 females and 65 males. There were 66 general surgical patients and 35 trauma patients. Fifty-six patients were referred on the same day as their admission.

The average length of stay with the APST was four days. Eleven patients were hemo-dynamically unstable on presentation and twelve were clinically septic. The reasons for referral were sepsis,[4] respiratory distress,[3] acute kidney injury AKI (38), post-operative care (31), pancreatitis,[3] ICU down-referral (15), hypoxia,[5] low GCS,[1] coagulopathy.[1] The mortality rate was 13%.

A total of thirty-six (35%) patients experienced 56 errors (1,5 errors per patient) The types of errors were fluid related in (30), drug related in,[11] indwelling device related errors in,[6] decision related errors[5] and failure to review investigations in.[5]

- The fluid related errors included the inappropriate discontinuation of intravenous infusions in three, the failure to institute fluids in twenty-four and the choice of an inappropriate fluid in three patients.
- The drug related errors included the administration of nephrotoxic agents to patients with AKI in four patients and the omission of thrombo-prophylactic agents or antibiotics in another four patients and incorrect dosing in three patients.
- The indwelling device errors involved the incorrect placement of indwelling devices, namely two central venous lines and one nasogastric tube, the inappropriate removal of a urinary catheter in two patients and the failure to remove a CVP in one patient.
- The decision errors involved the timing of endoscopic intervention in management of obstructive jaundice related sepsis in one patient, the operative management of gastro-intestinal bleeding in one, the need for laparotomy in two and the miss assessment of the severity of acute pancreatitis in one.
- Failure to review special investigations timeously was a cause of assessment error in five. In one patient with neutropenic sepsis the surgical team did not follow up on the microbiology results and failure to review routine blood results resulted in patients with AKI being overlooked for twenty-four hours. Failure to review a chest X-ray delayed the diagnosis of a misplaced CVP line and a pneumothorax misplaced feeding tube for twenty-four hours.

Table 2 tabulates the types of errors and classifies them according to cause. Errors of planning exceeded errors of execution and errors of omission, exceeded errors of commission. A total of 143 interventions were initiated by the APST. These included intravenous fluids (101), blood transfusion,[12] initiation or change of antibiotics,[9] management of neutropenic sepsis,[1] central line insertion,[3] optimization of oxygen therapy,[7] correction of electrolyte abnormality,[8] correction of coagulopathy.[2]

4. Discussion

The introduction of an APST was in direct response to our realization that our processes of care were inadequate and our belief that the post-operative and ward domain is a highly error prone environment. The results of this audit have confirmed that belief. The APST made a high number of interventions in this cohort of patients and detected errors and potential errors in over one third of patients. Furthermore the high mortality rate (13%) in this cohort suggests that human error is not particularly well tolerated in this group of patients. The causes of the error in this audit are in keeping with those reported in the literature where acts of omission are far more common than acts of commission.[5–8]

The majority of the errors and subsequent interventions involved adjusting pre-existing or instituting appropriate fluid management. The failure to initiate fluid management when indicated implies that the pathophysiology of surgical disease is poorly understood. The fluid shifts associated with the management of surgical sepsis and pancreatitis are not appreciated and are associated with poor decision-making. The surgical patients in this cohort were overwhelmingly septic and this is associated with significant fluid shifts. The management of post-operative fluid shifts requires clinical acumen and insight.

Drug related errors, involved either the failure to prescribe drugs when indicated, most commonly the omission of antibiotics for septic patients and the omission of thrombo-prophylaxis in high-risk patients, or the inappropriate administration of drugs, such as potentially nephrotoxic drugs in patients with renal dysfunction. Failure to review results may compound these errors as it may delay the diagnosis of AKI. Two strategies are required here. The first must prompt the question as to whether a new agent must be instituted and the second to must prompt a review of all current agents to see if any can be safely discontinued or are contra-indicated.

Inadequate decision-making is another common source of error. The failure to appreciate the physiological insult of a number of common acute surgical conditions is a frequent cause of error as is the failure to be conscious of the need to actively exclude well-known surgical complications. Delaying the endoscopic drainage of a patient with obstructive jaundice places that patient at increased risk for renal failure and sepsis. Logistical constraints may make it difficult to achieve but poor understanding of the clinical risk exacerbate these delays.

The insertion of indwelling devices is associated with a number of well-described complications. These include incorrect placement and iatrogenic pneumothorax following the insertion of a central venous line and incorrect placement with subsequent aspiration risks with naso-enteral feeding tubes. If these potential complications are not in the fore-front of the attending staffs minds then failure to chase up and review the post insertion X-ray's may result in these complications being undetected. It is important to stress that some of these complications may be detected by diligent clinical examination.

The above data may be helpful in designing further error reducing strategies. The use of tick boxes as a pre-operative safety strategy is well described and this has been adopted from the aviation industry.[13] Tick box style sheets my be useful in the ward situation as well and may even be designed to force clinical decisions and prompt appropriate intervention. A tick box for post operative management could be divided into headings based on the errors identified in this study, namely: Fluids, Drugs, Devices, Decisions and Special investigations. Common procedures such as central line insertion and closed tube thoracostomy are ideally suited to the development of formalized tick boxes. Designing a strategy to improve decision-making requires the defence in depth type approach and the APST system used in this audit is an example of this.[3,8] Patients are assessed, by multiple teams during their admission and this increases the chances of poor decisions being detected and corrected. Appropriate levels of seniority are vital for this to be effective.[2]

Table 2
Type of error compared to cause of error.

Type of error	Number	Planning	Execution	Omission	Commission
Drug related	11	8	3	4	7
Fluid related	30	24	6	27	3
[a]Device related	6	3	3	3	6
Decision related	5	4	1	4	1
[a]Failure to review investigations	5	0	5	5	0
Total	56	39	18	43	17

[a] There is overlap in these two groups as failure to review X-rays resulted in complications of indwelling device placement being overlooked. It can be argued that these should have been excluded clinically as well as radiologically.

5. Conclusion

High-risk acute surgical patients who are not admitted to ICU/HDU for whatever reason need to be appropriately catered for. This requires a level of care higher than what is available in a general ward. We have attempted to combine modern error theory with a simple risk stratification system to improve trauma and acute care surgery in our institution. This audit confirms that these patients are particularly vulnerable to human error and are not in a good position to tolerate error when it does occur. The high rate of interventions and error detection in this audit indicate that that our intervention has achieved its objective and should be continued and strengthened.

Ethical approval

This work was part of a Phd Proposal. The committee was the Biomedical Research Ethics Committee of the University of Kwa Zulu Natal BREC 104/010.

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None.

Author contribution

Dr Clarke is the surgical consultant who as part of his Phd research has instituted the Acute Physiological Support Team. He supervises it and manages the patients in conjunction with his junior staff.

Dr Kong and Dr Furlong were the first two medical officers to work in the APST. They helped develop it's ethos and style of care.

Dr Naidoo assisted with the collection of the error data.

Dr Aldous is a geneticist with a background in education and works as a post graduate facilitator. She is involved in developing the academic capacity of the Pietermaritzburg Complex.

Conflict of interest

None.

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