Cambridge Polytrauma Pathway: Are we making appropriately guided decisions?

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Abstract

Addenbrooke’s Hospital, the Major Trauma Centre for the East of England Trauma Network, received 1070 major trauma patients between 1st January and 31st December 2014. In order to improve care, an audit was performed of 59 patients meeting our own selection criteria for orthopaedic polytrauma between 1st January 2013 and 31st December 2013. The Cambridge Polytrauma Pathway was devised through NCEPOD guidelines, literature review, internal and external discussion. It facilitates provision of best practice Early Appropriate Care, encompassing – multidisciplinary consultant decisions around the patient in our Neurological and Trauma Critical Care Unit, early full body trauma CT scans, serial measurements of lactate and fibrinogen levels, and out-of-hours orthopaedic theatre reserved for life-and-limb threatening injuries. Re-audit was conducted of 15 patients meeting selection criteria, admitted between 1st October 2014 and 31st March 2015. Significant improvements in recording of lactate and fibrinogen were demonstrated, both on admission (lactate – p<0.000, fibrinogen – p<0.015), and preoperatively (lactate – p=0.003, fibrinogen – p<0.030). Time to trauma CT was unchanged (p=0.536) with a median time to CT of 0.53 h at re-audit (IQR 0.48–0.75). The number of patients receiving definitive orthopaedic intervention out-of-hours reduced from 8 to zero (p=0.195). The approach of facilitating management decisions to be made at early daytime MDT meetings has been adopted. It is anticipated that this pathway will improve outcomes in orthopaedic polytrauma patients and it is recommended that either the GOS-E, or the EQ-SD scoring systems be introduced to assess this.

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Introduction

Addenbrooke’s hospital, a UK Major Trauma Centre, serves a population of 5.9 million in the East of England and currently admits 1070 major trauma (Injury Severity Score > 15) patients annually, (as recorded between 1st January and 31st December 2014) [1,2]. In common with many centres in the UK there has been a focus on the development of care of trauma patients in the early phase of injury. Previously there was no defined clinical pathway following admission of polytrauma patients, for the management of orthopaedic injuries.

In order to address this shortfall we undertook a comprehensive examination of the process of care of orthopaedic polytrauma patients within Addenbrooke’s hospital and used this to design and implement a multi-professional pathway, focussed on delivering Early Appropriate Care (EAC) [3–5].

Patients and methods

The structure for the examination of care of polytrauma patients at Addenbrooke’s Hospital involved literature review followed by an audit of our practice. Our findings were discussed locally, regionally, and internationally at EFORT, and Canadian Orthopaedic Association (COA) conferences, before formulation and introduction of our pathway for Early Appropriate Care.

A literature review was conducted on key areas of care, set from multidisciplinary discussion and recommendations from the
National Confidential Enquiry into Peri-Operative Deaths (NCEPOD). We looked at; when definitive fixation should take place, what investigations should guide orthopaedic intervention, and who should be involved in decision-making.

“When should definitive orthopaedic fixation take place?”

Our literature review highlighted over 20 years of debate between two schools of thought; Early Total Care (ETC), and Damage Control Orthopaedics (DCO), culminating in the formulation of EAC [3–14]. EAC proposes a multidisciplinary approach to the polytrauma patient, recommending early definitive fixation of long bone or axial fractures, providing evidence of adequate physiological stability [3–5]. The concept of EAC is currently employed in military practice, with an emphasis on limited 60-min life or limb saving surgical intervention in patients not demonstrating evidence of physiological stability [6,7]. Our literature review also highlighted the risks of out-of-hours surgery, which has been associated with increased mortality due to reduced supervision and surgical fatigue [15–17].

“Which investigations should guide the decision to go to theatre?”

Injury Severity Score (ISS) is used to quantify the trauma ‘dose’, and is currently used by Major Trauma Networks and Trauma Audit and Research Network (TARN) to guide patient triage and outcomes respectively [2,4,18]. The ISS has been criticised due to a lack of specificity, and time taken for all injuries to become apparent, and hence physiological markers have been identified [4,5]. Higher lactate on admission, and a failure to normalise on resuscitation, has been shown to be the most specific marker of occult hypoperfusion; associated with higher risk of infection, multi-organ dysfunction and mortality [3,19–24]. Bleeding is the second most common cause of death in major trauma following neurological injury [25]. In major blood loss, low fibrinogen has been shown to indicate developing acute coagulopathy of trauma [26]. Early trauma computed tomography (CT) imaging has been fundamental to advances in trauma management, improving survival even in haemodynamically unstable patients [27–32]. NHS England standard contract for Major trauma Centres states a maximum time to CT of 60 min and ideal time of less than 30 min [33]. Addenbrooke’s own Trauma East Manual of Procedures and Operations (TEMPO) guidelines recommend CT within 30 min of admission and full reports to be available within 60 min [18,34,35].

“Who needs to be involved in the management decisions?”

The EAC model emphasises the role of the multidisciplinary team in polytrauma, with experienced consultant led decision-making at the helm [3,4,36]. Our literature review highlighted the following standards for our audit process.

1. 0% of definitive closed fracture orthopaedic fixations to take place out-of-hours (2000 h–0600 h).
2. 100% of patients to receive trauma CT scan within 60 min.
3. 100% of patients to have a recorded lactate within 24 h of admission and within 24 h of definitive orthopaedic surgical intervention.
4. 100% of patients to have a recorded fibrinogen within 24 h of admission and within 24 h of definitive orthopaedic surgical intervention.

All ISS >15 patients admitted to Addenbrooke’s Hospital, the East of England Major Trauma Centre, were identified from the TARN database. To these patients, our own selection criteria for orthopaedic polytrauma was applied, utilising a validated anatomical definition of polytrauma – AIS >2 of at least 2 body regions [37,38].

1. Admission to the Neurosciences and Trauma Critical Care Unit at Addenbrooke’s Hospital.
2. Abbreviated Injury Scale (AIS) >2 (severe) injury in at least 2 regions of the body.
3. Long bone or pelvic fracture with surgical intervention within 72 h of admission.

These criteria yielded 59 patients for the initial analysis (1st January 2013 to 31st December 2013) and 15 patients in the re-audit (1st October 2014 to 31st March 2015). Electronic medical records were used to collect the following data detailed in Table 1.

<table>
<thead>
<tr>
<th>Demographics:</th>
<th>Admission</th>
<th>Critical Care</th>
<th>Pre-operative</th>
<th>Post-operative</th>
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<tr>
<td>Age (years)</td>
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<tr>
<td>Sex (M/F)</td>
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<tr>
<td>Injury Severity Score (n)</td>
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<tr>
<td>Survival (Y/N)</td>
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<tr>
<td>Length-of-Stay (days)</td>
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<td>Time to CT (hours)</td>
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<td>Out-of-hours operation (Y/N)</td>
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<td>Timeline:</td>
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<td>Full Blood Count (Y/N)</td>
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<td>Haemoglobin (g/dL)</td>
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<td>Platelets (x10^9/mcL)</td>
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<td>Blood gas (Y/N)</td>
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<td>Lactate (mmol/L)</td>
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<td>pH Base Excess (mmol/L)</td>
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<td>Clotting Studies (Y/N)</td>
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<td>PT (s)</td>
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<tr>
<td>APTT (s)</td>
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<tr>
<td>Fibrinogen (g/L)</td>
<td></td>
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</table>
Survival was defined as 30-day all-cause mortality in accordance with methodology used by TARN. Patients repatriated to other hospitals on discharge were excluded from length-of-stay (LOS) analysis. Patients who arrived as transfers from other centres were excluded from time to CT analysis, as scans were conducted before arrival at Addenbrooke’s Hospital.

Further qualitative review of paper notes was conducted for out-of-hours cases to elaborate the circumstances around which the decision to operate was made. This process-of-care analysis was not used in the formal audit process, but used for internal departmental reflection, to guide formulation of the pathway, and support the need for change within the trust.

Data was recorded and analysed using Microsoft Excel (Microsoft Corp., Seattle, Washington, US). Statistical analysis was performed using GraphPad Prism (GraphPad Software Inc., La Jolla, California, US).

Our recommendations were discussed in local, regional and international forums and our finalised ‘Cambridge Polytrauma Pathway’ implemented at Addenbrooke’s Hospital. Data was re-audited from October 2014 to March 2015 to assess the impact of change.

Results

Initial audit of 59 patients meeting selection criteria yielded the following demographics (Table 2); 45 (76%) male with a median age of 35 years, 17 (29%) arrived as transfers from hospitals within the East of England Trauma Network. Median Injury Severity Score was 27, with 56 (95%) survivors and median length-of-stay (LOS) of 19 days. Admissions took place out-of-hours (2000–0600h) in 27 (46%) of cases. 8 (14%) patients had definitive orthopaedic fixations out-of-hours which comprised almost one third of out-of-hours admissions.

The 15 patients in the re-audit were not significantly different in terms of demographics (Table 2); 11 (73%) male (p = 1.000), median age 36 years (p = 0.353), 7 (47%) patients arrived by transfer (p = 0.223), the median ISS was 34 (p = 0.536), and all 15 (100%) survived (p = 1.000), with a median LOS of 19 days (p = 0.793). The number of out-of-hours definitive orthopaedic fixations taking place reduced to 0, however statistical significance was not achieved (p = 0.195).

Of the 30 initial audit non-transfer patients, median time to CT was 0.67 h (IQR – 0.42–0.86), with 35 (83%) taking place within 1 h and 13 (31%) within 30 min of admission. In re-audit of the 8 non-transfer patients the median time to trauma CT was 0.57 h (IQR – 0.48–0.75) (p = 0.536), with 7 (88%, p = 0.398) occurring within 1 h, and 2 (25%, p = 0.721) within 30 min of admission.

Within 24-h of admission in the initial audit 31 (61%) patients had a recorded lactate level and 12 (20%) had a fibrinogen level taken. In re-audit both of these showed statistically significant increases, with lactates recorded in 15 (100%) patients (p = <0.000) and fibrinogen levels recorded in 7 (47%) patients (p = 0.015). In the initial audit, in the 24-h period before orthopaedic surgical intervention 29 (49%) of patients had a recorded lactate and 8 (14%) a fibrinogen level. This increased significantly to 14 (93%) with a lactate (p = 0.003), and 6 (40%) with a fibrinogen level (p = 0.030).

Discussion

Addenbrooke’s Hospital, part of Cambridge University Hospitals, has been the Major Trauma Centre for the East of England Trauma Network since 2012. It has seen year-on-year increases in major trauma patient numbers – from 827 in 2012–2013 to 2012–2013. Given the increased strain on pathways of care proved by an extra 250 patients in 2014 our aim was to assess the quality and consistency in provision of care to major trauma patients with orthopaedic injuries. Performance was assessed according to a priori standards set by our literature review. Findings were

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**Table 2**

Audit data before and after the introduction of ‘Cambridge Polytrauma Pathway’.

<table>
<thead>
<tr>
<th></th>
<th>Initial Audit</th>
<th>Re-audit</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number n</strong></td>
<td>59</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td><strong>Transfers n (%)</strong></td>
<td>17 (29)</td>
<td>7 (47)</td>
<td>0.233*</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>35 (22–49)</td>
<td>36 (23–57)</td>
<td>0.333**</td>
</tr>
<tr>
<td><strong>Male n (%)</strong></td>
<td>45 (76)</td>
<td>11 (73)</td>
<td>1.000 *</td>
</tr>
<tr>
<td><strong>ISS</strong></td>
<td>27 (22–40)</td>
<td>34 (25–34)</td>
<td>0.536 *</td>
</tr>
<tr>
<td><strong>Survivors n (%)</strong></td>
<td>56 (95)</td>
<td>10 (100)</td>
<td>1.000 *</td>
</tr>
<tr>
<td><strong>Length-of-stay</strong></td>
<td>19 (13–35)</td>
<td>19 (14–26)</td>
<td>0.703 *</td>
</tr>
<tr>
<td><strong>Time to CT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hours</strong></td>
<td>0.67 (0.42–0.86)</td>
<td>0.53 (0.48–0.75)</td>
<td>0.536 *</td>
</tr>
<tr>
<td><strong>&lt; 0.5 h n (%)</strong></td>
<td>13 (31)</td>
<td>2 (25)</td>
<td>1.000 *</td>
</tr>
<tr>
<td><strong>&lt; 1 h n (%)</strong></td>
<td>33 (83)</td>
<td>7 (88)</td>
<td>1.000 *</td>
</tr>
<tr>
<td><strong>Out-of-hours</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Admission n (%)</strong></td>
<td>27 (46)</td>
<td>5 (33)</td>
<td>0.561 b</td>
</tr>
<tr>
<td><strong>Operation n (%)</strong></td>
<td>8 (14)</td>
<td>0 (0)</td>
<td>0.195 a</td>
</tr>
<tr>
<td><strong>24-h bloods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lactate n (%)</strong></td>
<td>36 (61)</td>
<td>15 (100)</td>
<td>&lt;0.000 *</td>
</tr>
<tr>
<td><strong>Fibrinogen n (%)</strong></td>
<td>12 (20)</td>
<td>7 (47)</td>
<td>0.015 a</td>
</tr>
<tr>
<td><strong>Pre-operative bloods</strong></td>
<td>29 (49)</td>
<td>14 (93)</td>
<td>0.003 *</td>
</tr>
<tr>
<td><strong>Fibrinogen n (%)</strong></td>
<td>8 (14)</td>
<td>6 (40)</td>
<td>0.030 a</td>
</tr>
</tbody>
</table>

**Fig. 1.** The ‘Cambridge Polytrauma Pathway’.

Patients meeting selection criteria for emergency surgery are transferred to out-of-hours trauma theatres. All patients received consultant multi-disciplinary input in a specialised critical care unit.
discussed at local, regional and international forums, resulting in formulation of the ‘Cambridge Polytrauma Pathway’ to achieve EAC (Fig. 1). Recommendations include:

1) Fast transit of patients from resuscitation in the emergency department to CT within 30 min of arrival.
2) Serial measurements of lactate and fibrinogen performed and recorded from admission to post-operative stability.
3) Critical patients with uncontrolled haemorrhage, ischaemic limb, compartment syndrome or grossly contaminated open fractures are transferred to theatre for 60-min life-or-limb saving surgery [6,7].
4) Patients who do not fit these criteria are transferred to the Neurological and Trauma Critical Care Unit (NTCCU) for resuscitation and stabilisation.
5) Daytime admissions receive urgent multidisciplinary input where a management plan can be organised.
6) Out-of-hours cases are discussed in an early morning MDT consultant meeting.
7) Orthopaedic patients who are physiologically and haemodynamically stable, receive definitive orthopaedic fixation on early daytime lists.

Following the introduction of the ‘Cambridge Polytrauma Pathway’, the proportion of patients receiving unnecessary out-of-hours definitive fixation reduced from 14% to 0% (p = 0.195). It is anticipated that a departmental change in practice regarding out-of-hours surgery will reduce incidence of inappropriate surgical complications with under-resuscitated polytrauma patient morbidity, and related poor long-term outcomes.

Whilst compliance with minimum standards set by NCEPOD for time to CT was good at 83% and 88% in audit and re-audit respectively, just 30% of audited patients met the EAST recommended 30 min CT targets, and no improvement was demonstrated in re-audit, with a reduction to 25% (p = 1.000). A failure to meet targets, may not be representative of all major trauma patients, as audited patients make up a subset of severely injured orthopaedic polytrauma patients. NCEPOD highlighted two key reasons for delays to CT nationally in MTCs – firstly unavailability of radiology room staff, and secondly location of CT scanner, with a lack of proximity of CT to resus rooms increasing the threshold at which patients are deemed stable for transfer. This is a problem that requires further local investigation if performance is to be improved [27-32].

Our pathway highlights the importance of lactate and fibrinogen as physiological markers of resuscitation and trauma-induced coagulopathy. Lactate is measured within minutes at the point-of-care, and currently is the only physiological marker used by Baltimore’s ‘Shock Trauma Center’ to guide fitness for surgery [39]. Serial lactates and a fibrinogen level should be taken on admission, during resuscitation, and throughout the operative period, to be used in the multidisciplinary setting to guide decisions about orthopaedic surgical intervention. Lactate recording improved dramatically in re-audit increasing from 61% to 100% on admission (p < 0.000), and 49%–95% pre-operatively (p = 0.003). Fibrinogen records in re-audit increased from 20% to 47% on admission (p = 0.015), 14%–40% pre-operatively (p = 0.030). Uptake of fibrinogen testing following the re-audit was noted to remain poor which may reflect the need for further dissemination of information, or the requirement for a point-of-care coagulation testing system such as rotational thromboelastometry (ROTEM) [40]. The ROTEM system was utilised by the British Army in Camp Bastion, Afghanistan, as a global measure of haemostatic function, and was found to help direct use of blood products in resuscitation [40,41]. However, a recent Cochrane Review highlighted a lack of current evidence for ROTEM, and recommended interventional studies measuring the effect of the use of ROTEM on patient outcome [42].

High quality care in major trauma systems relies on the consultant led multi-disciplinary team. Our pathway has made NTCCU the central hub around which trauma management decisions are made. A multidisciplinary team of acute care and surgical specialists, discuss all major trauma cases in an early morning meeting. It is anticipated that this will improve patient outcomes, through appropriate timing and sequence of intervention. The importance of critical care input and adequate resuscitation prior to definitive fracture care was highlighted by our literature review, and through discussions at local, regional and international forums, which led to the development of our pathway for providing EAC [3,4,14]. The ability to delay definitive fracture fixation until patients have been physiologically optimised has been shown to decrease length of stay, and normalising acidosis with a reduction in lactate levels is a powerful predictor of mortality [3,4,43]. By ensuring that lactate and fibrinogen are measured in our recommended timeframe and an MDT approach is used to inform management decisions, we hope the ‘Cambridge Polytrauma Pathway’ will reduce patient morbidity and ultimately improve Patient Reported Outcome Measures (PROMs).

Finally our audit highlighted a lack of sensitive measures of outcome in major trauma. In our patient groups neither mortality nor length-of-stay (LOS) were shown to significantly improve, with survival increasing from 95% to 100% (p = 1.000) and median LOS remaining at 19 days (p = 0.793). Survival is a crude measure of outcome in major trauma, and in particular the disability associated with orthopaedic injury [44-46]. A joint study by TARN and Cochrane systematic reviews, recommended more detailed outcome reporting in major trauma, using the Glasgow Outcome Scale – Extended (GOS-E), and the European Quality of Life 5D (EQ-5D) [45]. Ultimately, with health economics becoming increasingly important, parameters such as ‘return to work’ should also be incorporated in trauma PROMs.

Conclusion

The need for review of the management of polytrauma patients admitted to Addenbrooke’s Hospital as part of the East of England Trauma Network, was identified and conducted as a retrospective review of prospectively collected TARN data. Following introduction of the Cambridge Polytrauma Pathway the use of lactate and fibrinogen increased significantly. Awareness of the risks of out-of-hours operating has increased with the number of out-of-hours inappropriate definitive surgeries taking place during the re-audit period reduced to zero. Introduction of an early morning consultant MDT trauma meeting, and the creation of a central critical care hub for orthopaedic major trauma patients, will likely improve outcomes in terms of mortality and PROMs, through achieving Early Appropriate Care.

Conflict of interests

None.

References

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