Update in
Anaesthesia

The emergency laparotomy – principles and perioperative management

Ian Densham

Correspondence: idensham@nhs.net

Summary
The emergency laparotomy is a common procedure with high rates of morbidity and mortality. Recent national audits have shown wide variation in practice and outcomes. Outcomes are improved by implementation of clinical care pathways, emphasising early decision-making by experienced surgeons, early antibiotic administration, early operation involving a senior surgeon and anaesthetist, and appropriate postoperative care in a critical care facility.

INTRODUCTION

'Emergency laparotomy' has become a generic term encompassing several hundred specific non-elective abdominal surgical procedures.[1] So 'emergency laparotomy' patients are a heterogeneous group ranging from truly emergent cases, such as patients with life-threatening haemorrhage, to urgent cases with intra-abdominal sepsis and peritonitis and on to what we might term 'expedited' cases, such as those with adhesional bowel obstruction, who need a non-elective procedure if a trial of non-operative management is unsuccessful. In this article, the term 'emergency laparotomy' is used generically to describe the whole non-elective laparotomy population.

THE EMERGENCY LAPAROTOMY POPULATION

The first report of the UK's National Emergency Laparotomy Audit (NELA) demonstrated the heterogeneity of the population undergoing 'emergency laparotomy' (Table 1). Half of patients present with intestinal obstruction, which is due to adhesions in 57%, with the majority of the remainder (39%) due to malignancy; 11% of patients require surgery for complications of a recent elective abdominal procedure.[2]

The NELA report also demonstrated that emergency laparotomy patients form a diverse group in terms of age (Figure 1) and comorbid state. In the UK, 46% are over the age of 70 years, frequently with multiple comorbidities, in addition to acute pathophysiological changes caused by their surgical illness. As a group, therefore, their risk level is amongst the highest of all surgical patients.[3–5]

Thirty-day inpatient mortality rates following emergency laparotomy range from 13% to 18% – up to five times greater than what we would consider to be high-risk elective surgery, including major elective cardiac and vascular procedures.[1,6,7] In addition, major complication rates are as high as 50%.[1,6,7] This has been recognised in recent years with the publication

Table 1. *Recorded indications for performing emergency laparotomy.[2] Note that NELA was designed to investigate aspects of abdominal bowel surgery – children and procedures primarily relating to the gall bladder, biliary tree, pancreas and trauma were excluded from this audit. Both laparoscopic and open procedures were included*

Indication for surgery	Number of patients	Frequency (%)
Intestinal obstruction	9811	49
Perforation	4744	24
Peritonitis	4116	20
Ischaemia	1720	9
Abdominal abscess	1332	7
Sepsis: other	1474	7
Haemorrhage	819	4
Colitis	748	4
Anastomotic leak	618	3
Intestinal fistula	326	2
Abdominal wound dehiscence	116	0.6
Abdominal compartment syndrome	55	0.3
Planned relook	51	0.3
Other	1758	9

Ian Densham
Anaesthetic Specialty Training Registrar
Royal Devon and Exeter NHS Foundation Trust
Barrack Road
Exeter EX2 5DW
UK

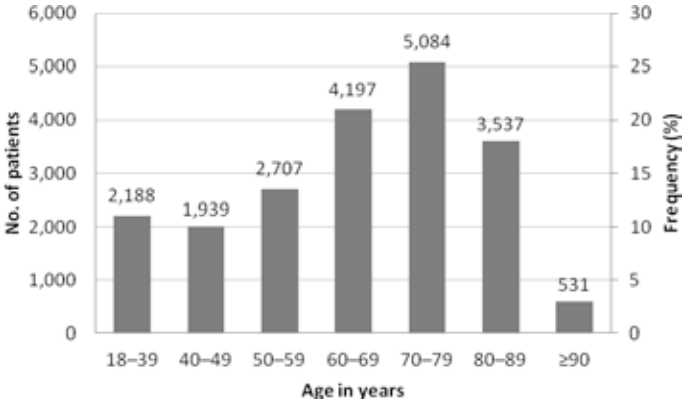

Figure 1. *Age of patients undergoing emergency laparotomy from the first NELA report*[2]

of several key documents that make recommendations for the care of such patients, with the aim of aiding decision making, channelling scarce resources and improving outcomes.[2,8–10] The Royal College of Surgeons' *The Higher Risk Surgical Patient* stands out as a very useful document that has been extensively used by regional and national groups in the UK in the design of clinical care pathways and quality improvement projects for this patient group.[9]

This article aims to bring together the main aspects of these recent recommendations, standards and quality improvement work to present a series of key principles and a clear and adaptable care pathway for these patients that can be applied in all manner of health care settings. The facilities available to manage these patients vary greatly around the world and the key themes can be adapted to local situations.

ASPECTS OF CARE

Identification of the high-risk patient and escalation of care

Patients with acute abdominal pathology may present to hospital via the emergency department (ED), as an inpatient on a ward, or via referral to a surgical assessment unit (SAU) from the community. In all patients, bedside observations should be taken immediately following admission or, in the case of inpatients, at the time of any clinical deterioration. Observations of respiratory rate, oxygen saturations, temperature, systolic blood pressure, heart rate and level of consciousness enable the calculation of an early warning score (EWS) (Table 2).[11] This score should be used by ward or ED staff to identify sick, high-risk patients and to escalate the patient's care appropriately from the outset. A middle or senior grade surgeon should review all patients with a high EWS (> 3) within 30 minutes of referral.[9] A more junior surgical doctor can assess patients with a lower EWS (< 3) and can take a thorough history, conduct an examination and carry out further investigations, ideally within an hour of arrival. Depending on availability investigations should include:

- full blood count
- creatinine and electrolytes
- liver function tests
- amylase
- glucose
- C-reactive protein (CRP)
- β-human chorionic gonadotrophin (HCG)/pregnancy test for women
- coagulation profile
- blood group and save
- ECG
- urinalysis
- arterial blood gas sample including lactate.

The timing of senior and/or consultant review and the pace of further investigation and intervention should reflect the severity of illness identified through these initial assessments and prompt a graded response depending on the presentation. However, a consultant surgeon should review all emergency surgical admissions within 12 hours of arrival, a standard that will require freedom from other routine commitments, such as elective operating lists and outpatient clinics.[2] In the case of many aspects of care of these patients, optimal performance may necessitate system changes such as redesign of surgeons' working patterns and job plans. For cases considered urgent

Table 2. *Early warning score*[11]

	Early warning score						
Physiological parameters	3	2	1	0	1	2	3
Respiratory rate (min^{-1})	≤ 8		9–11	12–20		21–24	≥ 25
Oxygen saturation (%)	≤ 91	92–93	94–95	≥96			
Supplementary oxygen		Yes		No			
Temperature (°C)	≤ 35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	
Systolic blood pressure (mmHg)	≤ 90	91–100	101–110	111–219			≥ 220
Heart rate (beats min^{-1})	≤ 40		41–50	51–90	91–110	111–130	≥ 131
Consciousness level				A			V, P or U

Consciousness level is graded according to the AVPU scale: A, awake; V, responds to voice; P, responds to pain; U, unresponsive.

or immediate, a consultant should be involved as early as possible to provide timely, invaluable experience in decision-making and enable the formulation of diagnostic and surgical care plans with an appropriate degree of urgency.

Some form of preoperative imaging is commonly required and may include ultrasound, an erect chest X-ray, abdominal X-ray or an abdominal CT scan. This may help clarify the extent and urgency of the procedure, although availability of the scan and the report should be weighed against the possibility of clinical deterioration as a result of delay. A system should be in place that enables the rapid request, performance and consultant reporting of the radiological investigation. Radiological investigation reported by a consultant radiologist is also associated with more accurate diagnostics and treatment planning.[12] Direct contact and explanation of the clinical features of the case, between the radiologist and a surgeon of at least registrar grade, is appropriate and effective.

Risk assessment and postoperative planning

The use of an objective risk assessment tool prior to surgery is recommended and must become incorporated into routine practice.[2] Routine use and clear documentation of a well-recognised scoring system will help determine the degree of urgency, mobilise appropriate resources in a timely manner, involve experienced senior staff, aid communication between clinicians and plan postoperative care (e.g. in the ICU). Importantly, it also enables the expected risk of death to be communicated to patients and their families, enabling a more informed decision to consent, and provides a more realistic understanding of the severity of the patient's situation. Expected risk of death scores will also be useful in discussions with patients who are exceptionally frail or unwell to the point at which surgical intervention would probably be futile and palliative care would be more appropriate.[2,9] Various scoring systems exist and may be based on the type of procedure, surgical urgency, pre-existing co-morbidity or current physiological derangement. Table 3 shows the elements of the P-POSSUM score,[13] a commonly used system available as an online calculator or a smart phone app for areas with limited internet access.

Regardless of the scoring system used, the ability to quantify risk and classify cases as high, medium or low risk will also be a determining factor in the postoperative destination of many patients. Depending on their predicted mortality, patients may be classified as follows:

Highest risk	> 10% risk of death
High risk	5–10% risk of death
Lower risk	< 5% risk of death

Recalculation of risk using the same tool as that used preoperatively may be used to re-evaluate the postoperative destination of the patient at the end of the procedure, as part of the continuous risk assessment that is central to the care of these patients.

Management of surgical sepsis

Sepsis describes a systemic inflammatory response to infection and is characterised by tachycardia, hypotension, tachypnoea, derangement in body temperature, low urine output and reduced cognitive ability, along with raised inflammatory markers and raised lactate. The end result is impaired oxygen delivery to the patient's organs and organ failure. Successful management of surgical sepsis is a race against time – failure to recognise the time-critical nature of clinical deterioration from surgical sepsis, and of treatment of the cause, has been shown to significantly increase mortality and the importance of timely intervention cannot be overemphasised.[14]

There are three key aspects to treatment of the source of sepsis:

1. administration of antibiotics
2. prevention of organ failure by haemodynamic resuscitation

Table 3. *Parameters of the P-POSSUM score.[13] Note that, for preoperative use, you must estimate the operative findings*

Physiological parameter	Operative parameters
Age	Operation type
Cardiac comorbidity	Number of procedures
Respiratory comorbidity	Operative blood loss
Systolic blood pressure	Peritoneal contamination
Pulse	Presence of malignancy
Glasgow Coma Scale score	CEPOD (Confidential Enquiry into Perioperative Deaths) classification
Haemoglobin White cell count Urea	Online calculator available at: http://www.riskprediction.org.uk/pp-index.php
Sodium Potassium Electrocardiogram	P-POSSUM formula Ln $R/1-R = -9.065 + (0.1692 \times$ physiological score$) + (0.1550 \times$ operative severity score), where $R =$ predicted risk of mortality

3. source control by surgical or radiological intervention.

The Surviving Sepsis Campaign guidelines describe the current evidence and guidance for management of sepsis very effectively.[15]

Administration of antibiotics

The immediate treatment of sepsis and septic shock comprises administration of oxygen, achieving good intravenous access and taking blood cultures prior to the administration of broad-spectrum antibiotics. This should occur concurrently with fluid resuscitation and within 1 hour of recognition of sepsis, as *there is an increase in mortality of around 8% for every 1-hour delay in antibiotic administration*.[15] If there is no clear indication for antibiotics (i.e. no suspicion of a perforation, peritonitis or sepsis), antibiotics should be considered during surgery, if indicated at that time.

The choice of antibiotics is guided by local practice and drug availability. A combination of drugs is chosen that is most likely to cover the wide variety of organisms implicated in peritoneal soiling due to bowel perforation. Options are shown in Table 4.

Fluid resuscitation

Fluid resuscitation is vital in maintaining haemodynamic performance and oxygen delivery to the tissues. If oxygen delivery to an organ is insufficient for its demands, then organ dysfunction results, followed by organ failure. For each sequential organ failure that develops due to sepsis, the patient's mortality risk increases by 15–20%.[16] Blood transfusion may be required in anaemic patients (Hb $< 70\,g\,L^{-1}$, $7\,g\,dL^{-1}$) to increase oxygen-carrying capacity and improve oxygen delivery ($\dot{D}O_2 = CO \times C_aO_2$). Cardiac output should be optimised with goal-directed fluid therapy (GDFT) – a fluid management strategy based on achieving predefined physiological parameters. Boluses of 250 mL of fluid of crystalloid should be administered and guided by frequent reassessment of the clinical picture including observations of heart rate, blood pressure and end-organ perfusion (consciousness state, urinary output and arterial blood lactate).

There has never been clear evidence to support the use of crystalloid over colloid, or vice versa, for fluid resuscitation. However, recent studies suggest an increased requirement for renal replacement therapy in patients receiving starch-based colloids and so there has been a shift away from using all colloids except albumin. Depending on available resources, cardiac output monitoring may help monitor the physiological response. There are many cardiac output monitors on the market, but little clear-cut evidence that they improve outcome. If available, take improvement in a parameter (e.g. stroke volume) of 8–10% following a fluid bolus as evidence that haemodynamic performance has improved. Vasoactive drugs should be used to treat hypotension unresponsive to adequate fluid resuscitation (i.e. 'septic shock'). Frequent, accurate recording of all observations and fluid balance is essential and urinary catheterisation and nasogastric tubes should be inserted routinely, although central venous pressure (CVP) measurement is of no proven benefit.

Surgical intervention and preventing delay

Whilst antibiotics will begin to control and moderate the effects of surgical sepsis, definitive source control is needed by radiological drainage or surgery. Access to radiology or an operating theatre may not be immediately available and possible delays should be considered and anticipated early. The potential for harm caused by delay for radiological investigation should be weighed against the benefits of the information it may provide. The type of imaging available, the

Table 5. *Proposed time frame to different urgencies of non-elective surgery, as used in the NELA UK audit*[2]

Urgency of surgery	Planned time from decision to operate to anaesthesia (hours)
Expedited	> 18
Urgent – B	6–18
Urgent – A	2–6
Immediate	< 2

Table 4. *Options for empiric broad-spectrum antibiotic cover in abdominal sepsis*

Amoxicillin 1 g IV 8-hourly, and Gentamicin 5 mg kg^{-1} IV 24-hourly, and Metronidazole 500 mg IV 8-hourly	Good cover for Gram-positive and Gram-negative bacteria and anaerobes
Cefuroxime 1.5 g IV 8 hourly, and Metronidazole 500 mg IV 8-hourly	Reasonable broad-spectrum cover, *Streptococcus faecalis* not covered by cefuroxime
Chloramphenicol 12.5 mg kg^{-1} (max. 1 g) IV 6-hourly, and Metronidazole 500 mg IV 8-hourly	If penicillin allergic
If complication of previous recent surgery, consider opting for more aggressive cover Tazocin 4.5 g IV 8-hourly or meropenem 1 g IV 8-hourly	
If upper GI perforation, consider addition of an antifungal drug such as fluconazole	

stability of the patient and the likelihood of changing management as a result of the investigation will all be factors in this decision.

Once the decision to perform laparotomy has been made, clear time goals should be established (Table 5), as delayed source control has an impact on survival.[14] Delays in access to theatre may be resource dependent and at times unavoidable, although where possible organisations should ensure that emergency theatre access matches demand. Avoidance of delay may simply be a case of good communication and theatre management on the ground, although there may be a need for

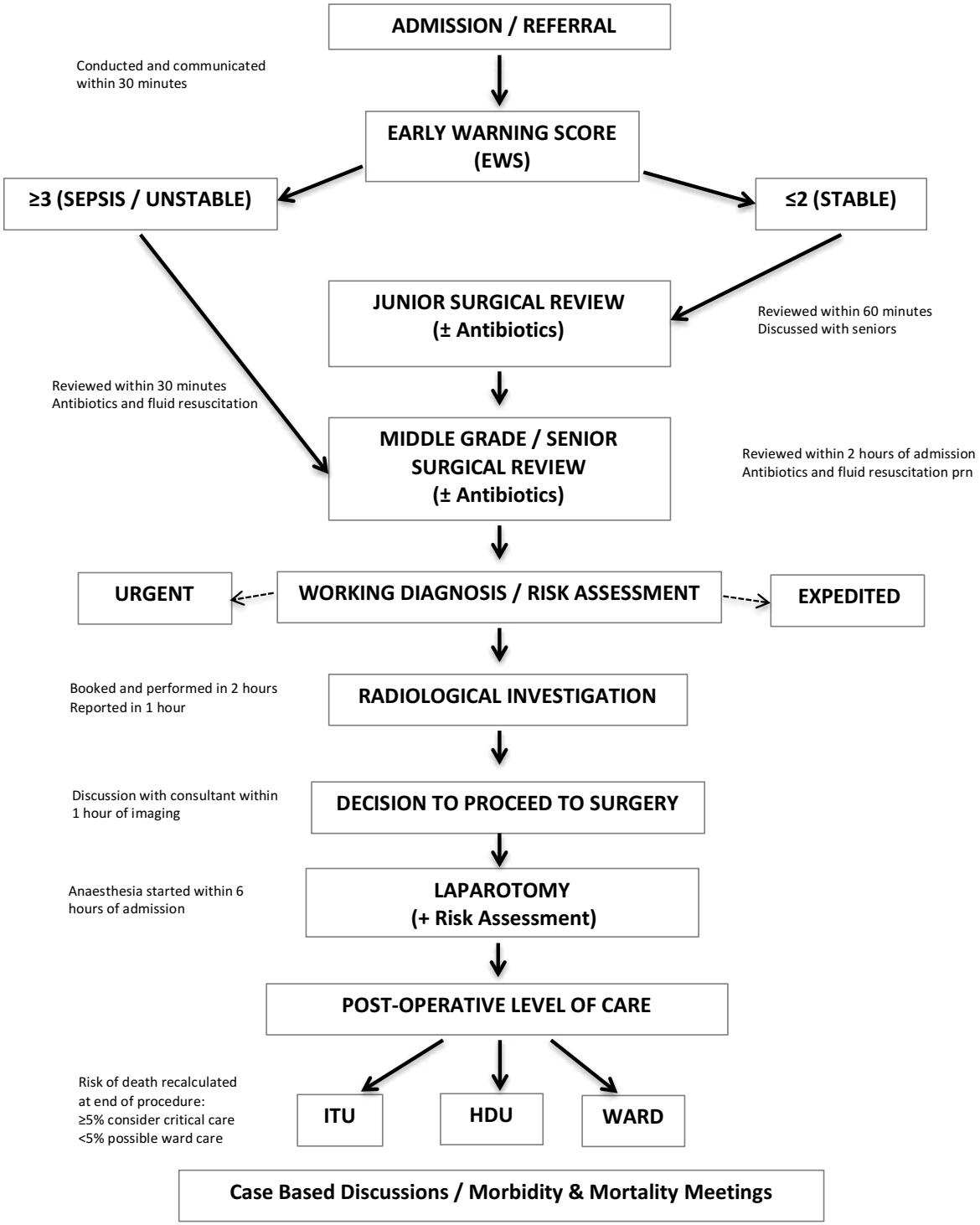

Figure 2. *Generic care pathway for non-elective laparotomy*

an institutional policy that permits prioritisation over elective cases or rota management changes. Surgical and anaesthetic documentation should accurately record the times of all significant events to enable high-quality audit and identification of specific reasons for delay.

Intraoperative care

Consultant-led care

Current best practice recommendations are that care for patients with a predicted mortality risk of > 10% should be delivered by a consultant surgeon and a consultant anaesthetist, regardless of the time of day.[2] In addition, any patient with a predicted mortality risk of > 5% should receive active input from both consultant surgeon and consultant anaesthetist.[2] There are obvious logistical and resource challenges in providing this level of service, and careful consideration needs to be given to the allocation and availability of senior clinicians. The involvement of senior clinicians is one aspect of care that has shown considerable variation according to the time of day when compared with other aspects such as the administration of antibiotics, provision of radiology or times to theatre.[2] Changes in working patterns, such as consultant on calls in blocks with more freedom from fixed commitments, may enable more frequent daily ward rounds and versatility. The benefits of senior decision-making are well recognised, although there is a clear need for training of future senior decision-makers and development of this experience in trainees. This is a delicate balance between patient safety, identification of risk and resource availability and this should be considered on a case-by-case basis. The routine use of formal case-based discussions or morbidity and mortality presentations following such cases can be extremely valuable in developing good clinical decision-making in trainees.

Anaesthetic management

- This should be consultant led.
- Implement on-going resuscitation – GDFT
- Administer antibiotics if not already given.
- Implement a lung-protective ventilation strategy.
- Institute an appropriate level of monitoring – insert an arterial line where possible, especially if ICU admission is planned. Monitor lactate. Insert a central venous catheter if administration of vasopressors is anticipated. Insert a urinary catheter.
- Remind the surgeon to send microbiological samples.
- If analgesia is required, insert rectus sheath catheters.[17]
- Insert nasogastric tube – confirm position at laparotomy and document.

Postoperative care

Critical care provision

The appropriate level of postoperative care must be decided by discussion between the surgeon, anaesthetist and intensivist. The P-POSSUM score should be recalculated using the accurate intraoperative findings. Admission to critical care should be based on the risk status of the patient. All high-risk patients should be considered for admission to either the high-dependency unit or ICU and those with a risk of death of > 10% should be admitted. Surgical factors are also important; patients with an open abdomen, in whom a return for a 'second look' in 24 hours is planned, may be best managed sedated and ventilated in the ICU. Careful consideration of risk at all stages is vital and a failure to assess risk properly results in failure to provide appropriate care.[2,8] Thorough risk assessments and treatment plans at an early stage will also avoid the misallocation of scarce resources and enable appropriate treatment limits to be set in some patients if critical care admission is not desired.

LOCAL SERVICE IMPROVEMENT

At the centre of recent efforts to improve the outcome of emergency laparotomy patients are local service quality improvement initiatives. These comprise the elements of clinical governance, including teaching and education, risk management and the development of guidelines and protocols, closely aligned with national and international standards. Effective care pathways that are specific to local resource availability and demands provide the framework with which to conduct high-quality local audit to establish baseline outcomes and identify areas for improvement. Figure 2 is an example of a generic care pathway for patients with an acute abdomen that may require non-elective laparotomy. The development of local documentation based on such a pathway can include the key indicators for audit which can ultimately be set against data from other institutions and national audit initiatives. The ELPQuIC (Emergency Laparotomy Quality Improvement Care) bundle is an example of how such a care pathway can lead to a significant reduction in the risk of death following emergency laparotomy.[18]

CONCLUSIONS

Patients undergoing emergency laparotomy are at high risk of adverse outcomes. Clinical care pathways adapted to the local environment may help streamline the care of these patients and provide the basis for local service improvement over time. Key elements of care for these patients include repeated risk assessment, early antibiotics and resuscitation and appropriate timely interventions provided by clinicians with the right level of experience.

REFERENCES

1. Saunders DI, Murray D, Pichel AC, Varley S, Peden CJ and members of the UK Emergency Laparotomy Network. Variations in mortality after emergency laparotomy: the first report of the UK Emergency Laparotomy Network. *Br J Anaesth* 2012; **109**: 368–75.
2. NELA project team. *First patient report of the National Emergency Laparotomy Audit*. Royal College of Anaesthetists, London; 2015. Available at: www.nela.org.uk.

3. Clarke A, Murdoch H, Thomas MJ, Cook TM and Peden CJ. Mortality and postoperative care after emergency laparotomy. *Eur J Anaesthesiol* 2011; **28**: 16–19.
4. Ingraham AM, Cohen ME, Raval MV, Ko CY, Nathens AB. Variation in quality of care after emergency general surgery procedures in the elderly. *J Am Coll Surg* 2011; **212**: 1039–48.
5. Peden CJ. Emergency surgery in the elderly patient: a quality improvement approach. *Anaesthesia* 2011; **66**: 440–5.
6. Al-Temimi MH, Griffee M, Enniss TM et al. When is death inevitable after emergency laparotomy? Analysis of the American College of Surgeons National Surgical Quality Improvement Program database. *J Am Coll Surg* 2012; **215**: 503–11.
7. Vester-Andersen M, Lundstrøm LH, Møller MH et al. Mortality and postoperative care pathways after emergency gastrointestinal surgery in 2904 patients: a population-based cohort study. *Br J Anaesth* 2014; **112**: 860–70.
8. Knowing the risk: a review of the perioperative care of surgical patients. *NCEPOD*, London 2011 Available at: www.ncepod.org.uk/2011poc.htm
9. The Higher Risk Surgical Patient. Report on the Peri-operative Care of the Higher Risk General Surgical Patient. The Royal College of Surgeons/Department of Health, London; 2011. Available at: www.rcseng.ac.uk/publications/docs/higher-risk-surgical-patient
10. NICE Clinical guideline CG50. Acute illness in adults in hospital: recognising and responding to deterioration (2007). Available at: https://www.nice.org.uk/guidance/cg50/resources/acute-illness-in-adults-in-hospital-recognising-and-responding-to-deterioration-975500772037
11. National Early Warning Score (NEWS) – Standardising the assessment of acute-illness severity in the NHS. The Royal College of Physicians (2015). Available at: https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news
12. Hillier JC, Tattersall DJ, Gleeson FV. Trainee reporting of computed tomography examinations: do they make mistakes and does it matter? *Clin Radiol* 2004; **59**: 159–62.
13. Risk Predication In Surgery. Available at: http://www.riskprediction.org.uk/index.php
14. Kumar A, Kazmi M, Ronald J et al. Rapidity of source control implementation following onset of hypotension is a major determinant of survival in human septic shock. *Crit Care Med* 2004; **32**(12 Suppl.): A158.
15. Dellinger RP, Levy MM, Rhodes A et al. and the Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock. *Intens Care Med* 2013; **39**: 165–228. Website: www.survivingsepsis.org
16. Vincent J-L, Sakr Y, Sprung CL, Ranieri VM et al. Sepsis in European intensive care units: Results of the SOAP study. *Crit Care Med* 2006; **34**: 344–53.
17. McDermott F, Wilson IH, Boorman P. Surgically placed rectus sheath catheters. *Update Anaesth* 2010; 26: 9–11. Available at: http://www.wfsahq.org/components/com_virtual_library/media/28d688d6c4e2f3b87630b72f9f7358b0–48ca7ca02d38e2984aed8491a953ad8b-Surgically-Placed-Rectus-Sheath-Catheters--Update-26-2010-.pdf
18. Huddart S, Peden CJ, Swart M, McCormick B, Dickinson M, Mohammed MA et al. Use of a pathway quality improvement care bundle to reduce mortality after emergency laparotomy. *Br J Surg* 2015; **102**: 57–66.