Impact of laparoscopic approach in emergency major abdominal surgery: single-centre analysis of 748 consecutive cases

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ABSTRACT

BACKGROUND Acute abdominal pathology requiring emergency laparotomy is a common surgical presentation. Despite its widespread implementation in other surgical procedures, laparoscopy, rather than laparotomy, is sparingly used in major emergency surgery. This study reports outcomes and impact of rising use of laparoscopy for a single high-volume district general hospital.

METHODS Data were retrieved from the prospective National Emergency Laparotomy Audit database for a 30-month period. Patient, procedural, and in-hospital outcome data were collated. Temporal trends were assessed and regression analysis conducted for clinical outcomes.

RESULTS A total of 748 consecutive cases were recorded. There was an increasing use of laparoscopy over the study period, with 49% of cases attempted laparoscopically in the final six-month interval. Patients treated laparoscopically were at reduced risk of mortality (odds ratio 0.114, 95% confidence interval 0.024 to 0.550) and experienced reduced length of intensive care stay (regression coefficient –1.571, 95% confidence interval –2.625 to –0.517) in multivariate adjusted analysis.

CONCLUSIONS Laparoscopy is safe and feasible in a large proportion of cases. It is associated with improved outcomes versus laparotomy.

KEYWORDS

Keyhole – Emergency – Laparotomy – Acute surgery – Laparoscopy

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Introduction

Abdominal pain requiring emergency laparotomy is a common surgical presentation with an estimated incidence rate of approximately 1:1000.1 Approximately 50,000 laparotomies per year are performed in England alone.¹ Mortality risk in these emergency patients is up to eight times higher compared with an elective setting.² While differences in hospital structural resources may be a major factor in the variability of emergency surgical outcomes, this factor alone is not necessarily indicative of individual patient care; discrete care processes may be just as important.³

Surgical practice has, in recent decades, been revolutionised by the laparoscopic approach. The benefits of accelerated recovery, reduced morbidity and mortality achieved through a less invasive approach are well established.^{4,5} However, despite being broadly adopted in elective surgery, uptake of laparoscopy in the emergency setting has been more varied. Most published on this topic has been context specific with reference to individual pathologies, with the strongest evidence for procedures such as

appendicitis, cholecystitis, and laparoscopy for non-specific abdominal pain.⁶

By contrast, the evidence for the use of laparoscopy for more major abdominal surgery, such as in the case of perforation, bowel obstruction or incarcerated hernia, is less well established. In the case of peptic ulcer perforation, for example, recent meta-analyses have found no difference in outcomes between open and laparoscopic approaches.^{7,8} Data from the UK National Emergency Laparotomy Audit (NELA) suggests that, for such major general surgical emergencies, the approach of choice still remains overwhelmingly open surgery (laparotomy), with only 13% of all major emergency general surgical cases attempted and 7% completed laparoscopically.⁹

In the 2012 guidelines for the use of laparoscopy in the acute abdomen, the European Association of Endoscopic Surgeons has gone as far as downgrading their recommendation level for laparoscopy in the case of perforated gastroduodenal ulcer, from +++ (the strongest available evidence) in the 2006 guidelines to ++ (strong evidence).⁶ The authors stated that this was based in part on a 2004 meta-analysis suggesting a higher reoperation rate

following laparoscopy,¹⁰ although more recent reviews have refuted this suggestion.^{7,8} Similar North American guidelines do not exist. We therefore appear that to have no clear recommendations on whether we should, and if so, when to, use laparoscopy in emergency major surgery.

NELA gave us the opportunity to prospectively assess our use of emergency laparoscopy. Queen Alexandra Hospital is 1200-bedded high-volume major district general hospital in the city of Portsmouth, serving a population of more than 600,000. Subspecialty consultant surgical teams with expertise in minimal access oesophagogastric, biliary and colorectal surgery provide 24-hour surgical emergency care, supported by critical care, renal, vascular and interventional radiological services, with access to two emergency theatres during the day to manage the demand. There is a strong culture of minimal access surgery for both elective and emergency surgery in our centre.

This study assesses a period following a change in the general surgical on-call from a single consultant general surgeon (without case-specific subspecialist care) to two consultant surgeons on call together, an upper and lower gastrointestinal surgeon, with the aim of providing subspecialist surgical expertise for all emergency cases, and the impact of an increasingly minimal access operative approach in emergency major abdominal surgery on patient outcomes.

Methods

Data were retrieved from a prospectively maintained database as part of our centre's institutional review board-approved submission to the NELA database, a national surgical registry. NELA records all intra-abdominal procedures with the exception of the following indications: vascular, gynaecological or trauma-related pathology, appendicitis, cholecystitis or hernia if not requiring bowel resection.¹¹ NELA data are subsequently compared with national Hospital Episodes Statistics data to assess data capture rates at an institutional level. Submitting institutions appoint a dedicated auditor to complete any outstanding data from the medical record thus ensuring complete data capture. Collection and use of these data have been approved by the national Health Research Authority.

Patient demographic, operative (indication, operative approach, seniority level of surgeon and anaesthetist) and outcome (postoperative disposition, length of stay, in-hospital mortality) data were retrieved for the period of January 2014 to June 2016, inclusive. The operative approach (open, laparoscopic, laparoscopic-assisted or converted to open) was recorded from the NELA database. Data included perioperative risk, patient morbidity and mortality risk assessment using the Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score (P-POSSUM), a well-validated surgical risk assessment score which incorporates physiological, biochemical, patient and pathological variables.^{12–14} Postoperative morbidity was not recorded.

Temporal trends were analysed by dividing data into five six-monthly intervals. Data for laparoscopy and laparotomy

were compared using appropriate non-parametric statistical tests. For the purposes of this analysis, laparoscopy was defined as all cases completed in a totally laparoscopic or laparoscopic-assisted manner (for example, for extracorporeal fashioning of bowel anastomosis). Laparotomy was defined as all cases where no laparoscopy was attempted or where a laparoscopic approach failed and was converted to laparotomy. Binary logistic and linear multiple regression analyses were performed for mortality and length of stay, respectively.

The following covariates were entered into regression models for mortality, overall length of stay and intensive care length of stay: patient age, gender, American Society of Anesthesiologists (ASA) grade, P-POSSUM morbidity risk, P-POSSUM mortality risk, surgeon seniority/grade, anaesthetist seniority/grade, operative approach (laparoscopic vs. open), postoperative disposition (transfer to ward or intensive care), operative findings, six-month time period of surgery. For length of stay analyses, in-hospital deaths were excluded.

All analyses were performed in Stata 12 software. Threshold for statistical significance was set at $P < 0.05$.

Results

Some 748 consecutive major general surgical procedures were recorded over the 30-month data collection period (Table 1). Ninety per cent (675/748) of all patients underwent preoperative diagnostic cross-sectional imaging (computed tomography).

Changes and trends over time

There was no significant change in patient demographics or perioperative risk as measured by P-POSSUM over time (Table 1). In standard UK practice, cases may be carried out by sufficiently senior and competent trainees, with senior support always available but not necessarily present in the operating theatre. Part of NELA is to increase consultant-led care; accordingly, differences were seen intraoperatively, with an increasing proportion of cases attended by consultant (attending) anaesthetists, which varied from 64.4% to 81.7% (mean 72.6%, $P = 0.001$). There was no significant difference in consultant surgeon presence, which ranged from 89.4–96.1%.

Operative approach was the only other significant change seen over the 30-month period. Laparoscopic or laparoscopic-assisted cases increased as a proportion of all cases from 20% to 37% ($P = 0.043$), with almost 50% of all cases attempted laparoscopically in the final six-month period (Fig 1). There was no significant change in the conversion rate, ranging from 14% to 16%. The effect of laparoscopy was therefore subjected to further analysis.

Laparoscopy compared with laparotomy

Assessing patients treated with laparoscopy compared with laparotomy, patients undergoing laparoscopy were significantly younger, with fewer comorbidities and at lesser risk of morbidity or mortality (Table 2). Patients treated with laparoscopy required significantly fewer days in hospital

Table 1 Demographic, perioperative and outcome trends over time. Absolute figures or median (range) reported unless otherwise indicated.

Time period	Jan–Jun 2014	Jul–Dec 2014	Jan–Jun 2015	Jul–Dec 2015	Jan–Jun 2016	Overall	P-value
Patients (n)	132	180	162	153	121	748	
Age (years)	65 (20–91)	68 (19–94)	70 (19–100)	69 (19–94)	70 (18–99)	68 (18–100)	0.064
Female sex (%)	55	52	52	59	54	54	0.729
ASA grade	3 (1–5)	3 (1–5)	3 (1–5)	3 (1–5)	3 (1–4)	3 (1–5)	0.199
P-POSSUM morbidity (%)	75.9 (17.5–100)	73.8 (15.3–99.9)	70.5 (17.5–99.9)	75.4 (15.3–100)	69.2 (19.9–99.9)	72.9 (15.3–100)	0.311
P-POSSUM mortality (%)	7.6 (0.7–99.1)	8.1 (0.6–93.9)	6.2 (0.7–93.3)	7.6 (0.6–99.8)	5.9 (0.8–94.8)	7 (0.6–99.8)	0.416
Consultant surgeon (%)	89.4	90.6	95.7	96.1	91.7	92.8	0.080
Consultant anaesthetist (%)	64.4	65.0	75.3	81.7	77.7	72.6	0.001
Laparoscopy (%)	20.5	28.3	31.5	34.6	37.2	30.3	0.043
Postoperative intensive care (%)	49.5	47.5	40.7	43.1	43.8	44.6	0.680
Length of stay (days)	15 (2–125)	13.5 (0–150)	16 (1–81)	26 (1–94)	13 (3–84)	15 (0–150)	0.220
In-hospital death (%)	8	11	8	10	7	9	0.649

ASA, American Society of Anesthesiologists; P-POSSUM, Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score.

(median 10 vs. 17 days, $P < 0.001$) and had suffered significantly less in-hospital mortality (2% vs. 15%, $P < 0.001$). Morbidity data were not available for analysis.

Considering the indications for surgery, bowel ischaemia, bowel perforation and hernias were more commonly treated with open surgery, whereas peptic ulcer perforation was more likely to be treated via the laparoscopic approach (Table 3).

Regression analysis

Controlling for all covariate factors, in-hospital mortality was significantly associated (overall regression model $P < 0.001$) with age, ASA grade, P-POSSUM morbidity score and operative approach (Table 4). Length of stay was

significantly associated (overall regression model $P < 0.001$) with P-POSSUM mortality score, age and postoperative intensive care (Table 5). Intensive care unit stay was significantly associated (overall regression model $P < 0.001$) with P-POSSUM mortality, age and operative approach (Table 6).

Discussion

This study considered the effect of surgical approach and practice trends over time for 748 consecutive cases of major abdominal surgery in a large tertiary district general hospital. We believe that it adds significant new evidence regarding the use of laparoscopy in major emergency general surgery, suggesting not only that it is feasible in up to one-third of cases but that it is safe to do so. It is associated with reduced lengths of stay, as well as reduced in-hospital mortality. In this large cohort single-centre analysis, operative approach was by far the strongest predictor for both mortality and length of stay, having controlled for patient and operative factors as well as operative findings and indications for surgery. Other non-patient factors, such as grade of anaesthetist or surgeon, or time period of surgery within the 30-month study period, were not significantly associated with any outcome.

The conversion rate seen in our data is roughly equal with the 15% rate reported in large international randomised trials of elective laparoscopic surgery,¹⁵ suggesting that comparable laparoscopic completion rates in emergency surgery should be achievable in other centres as well.

Peer-reviewed publications and national enquiries such as the UK National Confidential Enquiry into Patient

Figure 1 Increasing use of laparoscopy over time for major abdominal surgery

Table 2 Comparison of demographic and outcome data for laparotomy and laparoscopy. Absolute values and median (range) given unless otherwise stated.

Parameter	Laparotomy	Laparoscopy	P-value
Patients (n)	520	228	
Age (years)	73 (19–99)	66 (18–96)	< 0.001
Female sex (%)	57%	52%	0.216
ASA grade	3 (1–5)	2 (1–4)	< 0.001
P-POSSUM morbidity (%)	75.4 (19.9–100)	66.6 (17.5–99.3)	< 0.001
P-POSSUM mortality (%)	8.9 (0.8–99.8)	5.8 (0.7–77.8)	< 0.001
Consultant surgeon (%)	92	93	0.822
Consultant anaesthetist (%)	71	73	0.683
Postoperative intensive care (%)	53.2	25.7	< 0.001
Length of stay (days)	17 (1–87)	10 (3–94)	< 0.001
In-hospital death (%)	15	2	< 0.001

ASA, American Society of Anesthesiologists; P-POSSUM, Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score.

Table 3 Operative findings and surgical approach.

Operative findings	Laparotomy, n (%)		Laparoscopy, n (%)	
	(n)	(%)	(n)	(%)
Adhesions	232	31	217	29
Ischaemia**	157	21	45	6
Bowel perforation*	157	21	82	11
Localised malignancy	75	10	75	10
Hernia*	67	9	30	4
Abscess	52	7	75	10
Stricture	45	6	30	4
Disseminated malignancy	45	6	60	8
Volvulus	30	4	22	3
Fistula	22	3	45	6
Colitis	15	2	15	2
Diverticulitis	15	2	15	2
Ulcer haemorrhage	15	2	0	0
Bleeding	15	2	15	2
Peptic ulcer perforation**	15	2	90	12
Anastomotic leak	7	1	22	3
Compartment syndrome	7	1	0	0

All comparisons non-significant except where indicated.
*: p<0.01, **: p<0.001

Table 4 Regression modelling results: in-hospital mortality (binary logistic regression).

Covariate	Odds ratio	95% confidence interval	P-value
Age	0.972	0.946–0.999	0.040
ASA grade	5.434	1.165–25.335	0.025
P-POSSUM morbidity	0.957	0.924–0.991	0.013
Laparoscopy	0.114	0.024–0.550	0.007

ASA, American Society of Anesthesiologists; P-POSSUM, Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score.

Outcome and Death (NCEPOD) alike have highlighted the variability of patient outcomes following emergency surgery.^{3,16,17} Investigated underlying causes have largely focussed on factors such as patient characteristics, hospital staffing levels, prompt availability of diagnostic tools and lack of operating theatre capacity. However, other studies have suggested that this variability can be assumed to extend to the surgical approach as well. While no data on major surgery are available, large national audits of appendectomy and cholecystectomy have shown extreme variations in the application of laparoscopy, in the case of appendectomy varying between 0% and 100%.^{18,19}

Improving structural hospital factors, as recommended by the National Confidential Enquiry into Patient Outcome

Table 5 Regression modelling results: length of hospital stay (linear regression).

Covariate	β coefficient	95% confidence interval	P-value
P-POSSUM mortality	0.093	0.066 to 0.120	< 0.001
Age	-0.031	-0.056 to -0.007	0.014
Postoperative intensive care	2.887	1.816 to 3.958	< 0.001
P-POSSUM, Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score.			

Table 6 Regression modelling results: length of intensive care stay (linear regression).

Covariate	β coefficient	95% confidence interval	P-value
P-POSSUM mortality	0.123	0.097 to 0.150	< 0.001
Age	-0.037	-0.064 to -0.011	0.006
Laparoscopy	-1.571	-2.625 to -0.517	0.004
P-POSSUM, Portsmouth Physiologic and Operative Severity Score for the enUmeration of Mortality and morbidity score.			

and Death, although undoubtedly important, may involve difficult organisational change or prohibitive expense. Conversely, encouraging increased use of emergency laparoscopy may represent a cost-effective means of improving outcomes, resulting in additional resource benefits for health systems if lengths of stay, morbidity and mortality can be reduced.

Minimally invasive surgery, compared with an open approach, results in reduced pain and surgical inflammatory response,²⁰ resulting in improved mobility, earlier discharge and reduced morbidity and mortality.^{4,5} The findings of this study are in agreement with the many published analyses of laparoscopy in the elective setting and suggest that greater use of laparoscopy is feasible and can be safely considered in emergency surgery.

This is a preliminary non-randomised single-centre study with some limitations. Although we attempted to control for a large number of patient and operative factors, not all of these factor into a surgeon's consideration for which surgical approach may be most appropriate. Patient body habitus, for example, was not included, nor was the likelihood of severe adhesions, or degree of intestinal distension in the case of obstruction, all of which may predispose a surgeon to opting for an open approach. In the severely unwell patient, the open approach may be preferable, owing to the potentially reduced operative time and avoidance of pneumoperitoneum. Recording these confounders (and in some cases, having the valid means to assess them) would allow greater inferences to be made in future. Our focus on the feasibility the minimally invasive approach meant that our analysis was not conducted as an intention to treat. The patient cohort presented in this study included a sample comparable to nationally reported data with median predicted mortality between 5–9.9%.⁶

Few international data regarding major emergency laparoscopic surgery are available. National UK data indicate a national average of 13% of attempted laparoscopic cases. Despite the limitations of this study, the data presented here suggest that this figure could be increased and that a laparoscopic approach could be considered in up to 50% of patients. This has been shown to be a safe and achievable intervention to improve care. Surgeon experience and ability must obviously be considered, as well as the potential implications for surgical training of such a change. We have achieved these higher rates of laparoscopy in our institution as a result of direct involvement of subspecialty consultants, skilled in advanced minimal access surgery, in the care of our emergency patients. Patient selection will remain key; in our data, we report that the majority of procedures performed for bowel ischaemia, perforation or hernia were performed open whereas (with the exception of preferentially laparoscopy for perforated peptic ulcers), for all other indications, the approach was equivocal and will have been guided by patient factors rather than the diagnosis.

We believe that these findings further add to the current debate on whether emergency general surgeons or subspecialty surgeons should run the emergency surgical take in the UK, and appear to support the latter.

In summary, we believe this large cohort single-centre analysis supports the safety and feasibility of a pro-laparoscopic approach in emergency general surgery. Having established this approach in our institution, half of our procedures now begin and more than 50% are completed laparoscopically. This approach appears to be safe with better outcomes and similar conversion rates to those in elective general surgery. We would like to see further study to confirm these findings over time with larger numbers and in other institutions.

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