

# Laparoscopy in major abdominal emergency surgery seems to be a safe procedure

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## ABSTRACT

**INTRODUCTION:** Laparoscopy is well established in the majority of elective procedures in abdominal surgery. In contrast, it is primarily used in minor surgery such as appendectomy or cholecystectomy in the emergent setting. This study aimed to analyze the safety and effectiveness of a laparoscopic approach in a large cohort of major abdominal emergencies.

**METHODS:** A population-based cohort from the Region of Copenhagen, Denmark, including  $n = 1,139$  patients undergoing major abdominal emergency surgery in 2012.

**RESULTS:** A total of 313 patients were operated with an initial laparoscopic approach; 37% were laparoscopically completed and 63% of the operations were converted to a laparotomy. Most conversions (40%) were for performing a bowel resection, 35% were due to inadequate exposure, 2% were converted due to accidental bleeding and 7% due to iatrogenic injuries. The reoperation rate was 17% in the laparoscopically completed group versus 19% in the group converted to laparoscopy and 20% in the open group. Major complications occurred after 31.6% of the laparoscopically completed operations, after 46.4% of the converted operations and after 49.5% of the open operations. The median length of stay was eight days in the laparoscopic group, 12 days in the converted group and 11 days in the group of open operations.

**CONCLUSIONS:** In a large, unselected group of major abdominal emergencies, we report a low rate of complications for operations conducted by an initial laparoscopic approach, and a high rate of conversion to open surgery, with 10% of the entire study population obtaining the benefits of a laparoscopic approach.

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In many areas of abdominal surgery, laparoscopy has improved outcomes and has therefore become the gold standard in the majority of elective procedures, effectively replacing open surgery [1-5].

In the emergent setting, laparoscopic procedures are well established in cholecystectomy for acute cholecystitis and appendectomy for acute appendicitis, where the laparoscopic technique is generally safe and associated with a decrease in post-operative morbidity, pain, and time to return to work [6, 7].

Laparoscopy has also been introduced in operations for perforated peptic ulcers and small bowel obstruction (SBO), where it may improve the early post-operative outcome, reduce the number of negative laparotomies and facilitate the selection of an appropriate incision in case of a laparotomy [4, 5, 8-12].

Several studies have made retrospective reviews of laparoscopy in unselected patients pre-senting with acute abdomen (all including suspected cholecystitis and appendicitis). These studies conclude that laparoscopy is safe and feasible in acute abdominal surgery [1-3, 13-15].

However, the safety and efficacy of an initial laparoscopic approach in abdominal emergencies is difficult to assess because of the limited and very heterogeneous series published, none of which focus on major abdominal emergency surgery. This present study aimed to analyze the feasibility and safety of an initial laparoscopic approach in a large and unselected cohort of major abdominal emergencies.

## METHODS

This was a retrospective, observational multicentre cohort study of patients aged  $\geq 18$  years undergoing unselected high-risk emergency gastrointestinal surgery in 2012 in the Capital Region of Denmark, with a population base of 1.66 million.

Only patients operated in a small centre located on the island of Bornholm (40,000 inhabitants) and patients operated in one highly specialized centre (covering trauma, liver transplants and elective surgery of the oesophagus, stomach, liver and pancreas without unselected reception of emergency surgery patients) were not included. These patients represent less than 5% of the emergency laparotomies performed in the region, effectively making the study population-based.

Trauma surgery, appendectomies, cholecystectomies, simple hernia surgery without bowel resection and negative/purely diagnostic laparoscopies/laparotomies were excluded. Data were obtained from a central patient record system including actual operative charts used in the Capital Region of Denmark. We ensured 100% follow-up, with a group of surgeons reviewing the charts and entering the relevant information in a pre-specified database. Complications were graded according to the Clavien-Dindo classification [16], omitting

## ORIGINAL ARTICLE

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TABLE 1

Characteristics and type of initial surgical approach: laparoscopic or open surgical technique in major emergency surgery patients, Capital Region of Denmark, 2012 (N = 1,139).

	Initiated laparoscopy (n = 313)	Open surgery (n = 826)	p-value
Age, mean, yrs	64.8	68.6	0.02
Sex, n (%) [95% CI]			0.37
Female	173 (55.3 [49.6-60.9])	432 (52.3 [48.8-55.8])	
Male	140 (44.7 [39.1-50.4])	394 (47.7 [44.2-51.2])	
ASA-score, n (%) [95% CI]			< 0.001
1-2	206 (65.8 [60.3-71.1])	409 (49.5 [46.1-53.0])	
> 3	107 (34.2 [28.9-39.7])	417 (50.5 [47.0-53.9])	
ECOG performance score, n (%) [95% CI]			0.003
0	169 (56.5 [50.7-62.2])	353 (45.0 [41.4-48.5])	
1-2	109 (36.5 [31.0-42.2])	352 (44.8 [41.3-48.4])	
3-4	21 (7.0 [4.4-10.5])	80 (10.2 [8.2-12.5])	
Missing data	14	41	
Sepsis score, n (%) [95% CI]			0.003
0	104 (43.0 [36.7-49.5])	332 (53.7 [49.7-57.7])	
1-2	119 (49.2 [42.7-55.8])	220 (35.6 [31.8-39.5])	
3-4	19 (7.9 [4.8-12.0])	66 (10.7 [8.4-12.4])	
Missing data	71	208	
Previous abdominal surgery, n (%) [95% CI] <sup>a</sup>	144 (46.0 [40.4-51.7])	508 (61.6 [58.1-64.8])	< 0.001
Radiology, n (%) [95% CI]			0.02
CT	239 (76.4 [71.3-81.0])	689 (83.4 [80.7-85.9])	
Conventional X-ray	9 (2.9 [1.3-5.4])	16 (1.9 [1.1-3.1])	
Surgery, n (%) [95% CI]			0.001
Primary surgery	239 (76.4 [71.3-81.0])	699 (84.6 [82.0-87.0])	
Intervention after elective surgery	74 (23.6 [19.0-28.7])	127 (15.4 [13.0-18.0])	
Indication for surgery, n (%) [95% CI]			< 0.001
Radiologic signs of pneumoperitoneum	113 (36.5 [31.1-42.1])	171 (20.8 [18.0-23.7])	
Bowel obstruction	70 (22.6 [18.0-27.6])	449 (54.5 [51.0-57.9])	
Upper GI endoscopy/colonoscopy/sigmoideoscopy converted to laparoscopic or open surgery	2 (0.7 [0.08-02.3])	34 (4.1 [2.9-5.7])	
Clinical evaluation	67 (21.6 [17.2-26.6])	104 (12.6 [10.4-15.1])	
Other	58 (18.7 [14.5-23.5])	66 (8.0 [6.3-10.1])	
Missing data	3	2	

ASA = American Society of Anesthesiology; CI = confidence interval; ECOG = Eastern Cooperative Oncology Group; GI = gastrointestinal.

a) Laparoscopic and/or open abdominal surgery.

registration of Clavien-Dindo complications grade 1 (i.e. use of intravenous fluid post-operatively, etc., which is standard procedure in the context of emergency laparotomy). Complications with a Clavien-Dindo grade above 2 were considered major. Only the first emergency laparotomy/laparoscopy in a sequence of laparotomies was registered, and reoperation within 30 days of emergency laparotomy/laparoscopy was considered a complication.

The patient characteristics extracted were age, gender, American Society of Anesthesiology (ASA) score, Eastern Cooperative Oncology Group performance score, sepsis score, previous abdominal surgery, preoperative radiology, primary intervention or initial intervention after elective surgery, indication for surgery and type of surgery performed; open, laparoscopic or converted laparoscopic.

The surgical approach with open or laparoscopic

technique was selected by the surgeon and not based on objective criteria. The recorded outcomes of interest were rate of laparoscopic procedures, rate of conversion from laparoscopic to open procedure, reasons for conversion, duration of surgery, length of hospital stay (LOS), and intra- and post-operative complications, including 30-day mortality.

Approval of the study was obtained from the Danish Health and Medicines Authority (3-3013-556/1/EFOM) and the Danish Data Protection Agency (2007-58-0015).

### Statistics

95% confidence intervals for estimates were calculated, with non-overlapping of confidence seen as a significant difference. SAS ver 9.4 was used in performing all calculations.

*Trial registration:* not relevant.

## RESULTS

During the one-year period, 1,139 emergency procedures were recorded, 313 patients had a laparoscopic procedure. Among these procedures, 115 (37%) were laparoscopically completed and 198 (63%) were converted to a laparotomy. Most laparoscopies (72%) were performed or supervised by a consultant or staff specialist and 28% were performed by a surgeon in training.

Patients with an initial attempt of laparoscopic surgery were younger, had a lower ASA score and a lower frequency of previous abdominal surgery than patients who had an initial laparotomy. More patients in the initial laparoscopy group were operated for free air on radiological examination or based on a clinical evaluation alone, while operation for bowel obstruction was more frequent in initial laparotomy patients (Table 1).

Most conversions (40%) were caused by the need for open bowel resection, 35% of conversions were caused by inadequate exposure, 2% were due to bleeding and 7% were due to specified iatrogenic injuries. In the group with iatrogenic injuries, three (21%) patients were converted to open surgery due to bleeding and 11 (79%) due to accidental enterotomy. Two (1%) patients had bowel perforations from Veress needle insertion, four (2%) patients had bowel perforations caused by a grasper lesion, and five (2.5%) patients had an unspecified bowel lesion during mobilization of the bowel (Table 2). One patient (0.9%) in the laparoscopically completed group had an undiscovered iatrogenic injury that required a laparotomy for an initially overlooked bowel perforation.

The study had no guideline for creating pneumoperitoneum; and in 110 patients (35%) we do not know exactly how it was created (some trocars in this group were blindly inserted). A total of 98 patients (31%) had pneumoperitoneum established with Veress needle, seven (2%) by Palmer's point and the rest umbilically. The Hasson technique was used in 69 patients (22%); and in 36 patients (12%) the old incisions were opened and the trocar introduced under direct vision (reoperations).

The duration of operation (median, interquartile range) was 131 (98-177) minutes in the converted group and 86 (68-117) minutes in the laparoscopically completed group, compared with 120 (79-177) minutes in the open group.

More than 50% of the procedures for perforated ulcer that did not require resection and more than 40% of the procedures for SBO were completed laparoscopically. Almost all procedures for non-perforated diverticulitis and more than a third of the procedures for anastomotic leak were also completed laparoscopically (Table 3).

The reoperation rate was 17% in the laparoscopic-



TABLE 2

Conversions from an initially laparoscopic approach to open surgical procedure in major emergency surgery patients, Capital Region of Denmark, 2012 (N = 313)<sup>a</sup>.

	n (%) (N = 198)
Need for resection <sup>b</sup>	79 (39.9)
Inadequate exposure <sup>c</sup>	70 (35.4)
Dense adhesions <sup>d</sup>	31 (15.7)
Respiratory problems due to pneumoperitoneum	2 (1.0)
Bleeding	2 (1.0)
<i>Iatrogenic injury</i>	
Bleeding	3 (1.5)
Bowel perforation due to Verres needle	2 (1.0)
Bowel perforation due to grasper lesion	4 (2.0)
Bowel perforation due to mobilization	5 (2.5)
Subtotal	14 (7.1)

a) 115 patients were not converted.

b) Small bowel resection: 26, ileocaecal resection: 5, right hemicolectomy: 17, transverse resection: 1, left hemicolectomy: 3, sigmoid resection: 16, rectum resection: 1, colectomy: 8, resection of small bowel and colon: 2.

c) Insufficient pneumoperitoneum, anatomy and/or pathology unclear, intraabdominal fluid/peritonitis, not possible to come in position laparoscopic, small bowel resection: 3, ileocaecal resection: 3, right hemicolectomy: 1, left hemicolectomy: 1, sigmoid resection: 3.

d) Small bowel resection: 1, ileocaecal resection: 1, right hemicolectomy: 1, sigmoid resection: 2, rectum resection: 1.



TABLE 3

Intraoperative findings in patients having a laparoscopic procedure in major emergency surgery patients, Capital Region of Denmark, 2012 (N = 313). The values are n (%) [% of procedure].

	Laparoscopic completed surgery (n = 115)	Laparoscopic converted to open procedure (n = 198)
Small bowel obstruction	28 (24.3) [41]	41 (20.7) [59]
Perforated ulcer	27 (23.4) [46]	32 <sup>a</sup> (16.1) [54]
Colonic perforation, other	11 (9.6) [28]	29 (14.1) [72]
Diverticulitis, no perforation	11 (9.6) [92]	1 (0.5) [8]
Anastomotic leak	9 (7.8) [36]	16 (8.1) [64]
Perforated diverticulitis	5 (4.3) [24]	16 (8.1) [76]
Tumour	5 (4.3) [33]	10 (5.1) [67]
Bleeding	2 (1.7) [22]	7 (1.0) [78]
Ischaemic bowel, not resectable	2 (1.7) [40]	3 (1.5) [60]
Ischaemic bowel, resectable	0	30 (15.2) [100]
Small bowel perforation	0	9 (4.5) [100]
Other	15 (13.0) [79]	4 (2.0) [21]

a) 6 with Billroth II resection.

ally completed group versus 19% in the laparoscopic converted group and 20% in the open group. The most frequent cause for reoperation in the converted group was wound dehiscence (Table 4). In six of 14 patients, an iatrogenic injury was followed by a reoperation. In the laparoscopically completed group, 18% of the patients were admitted to an intensive care unit (ICU), 5% of the patients for 1-2 days and 9% for more than seven days. In the converted group, 40% were admitted to an ICU, 10% for 1-2 days and 17% for more than seven days. The

TABLE 4

Surgical complications and conversion status in major emergency patients with an initially laparoscopic approach, Capital Region of Denmark, 2012 (N = 313). The values are n [% (95% CI)].

	Laparoscopic completed surgery (n = 115)	Laparoscopic converted to open procedure (n = 198)
No complications	99 (86 [78.4-91.8])	160 (81 [74.6-86.0])
Internal hernia	2 (1.7 [0.2-6.1])	0 (0 [0-1.9])
Bowel perforation	1 <sup>a</sup> (0.9 [0.02-4.7])	4 (2.0 [0.6-5.1])
Intraabdominal abscess	2 (1.7 [0.2-6.1])	1 (0.5 [0.01-2.8])
Reperforated ulcer	3 (2.6 [0.5-7.4])	1 (0.5 [0.01-2.8])
Bleeding ulcer	0 (0 [0-3.1])	2 (1.0 [0.1-3.6])
Laparoscopy, suspected reperforated ulcer	2 (1.7 [0.2-6.1])	0 (0 [0-1.9])
Stomal necrosis/stoma revision	2 (1.7 [0.2-6.1])	3 (1.5 [0.3-4.4])
Perforated diverticulitis	1 (0.9 [0.02-4.7])	0 (0 [0-1.9])
Bowel obstruction	2 (1.7 [0.2-6.1])	0 (0 [0-1.9])
Ischaemic bowel	1 (0.9 [0.02-4.7])	4 (2.0 [0.6-5.1])
Laparotomy, negative	1 (0.9 [0.02-4.7])	0 (0 [0-1.9])
Anastomotic leak	0 (0 [0-3.1])	3 (1.5 [0.3-4.4])
Bleeding	0 (0 [0-3.1])	2 (1.0 [0.1-3.6])
Fascia rupture	0 (0 [0-3.1])	12 (6.1 [3.2-10.3])
Superficial wound dehiscence	0 (0 [0-3.1])	5 (2.5 [0.8-5.8])
VAC treatment	0 (0 [0-3.1])	10 (5.1 [2.5-9.1])
Skin graft	0 (0 [0-3.1])	1 (0.5 [0.01-2.8])
> 1 complication	2 (1.7 [0.2-6.1])	7 (3.5 [1.4-7.2])

CI = confidence interval; VAC = vacuum-assisted closure.

a) An undiscovered iatrogenic injury.



Laparoscopy is safe as an initial approach in major abdominal emergencies.

overall mortality (95% confidence interval (CI)) was 8.5% (3.4-13.7%) after a laparoscopic procedure, 18.4% (12.9-23.8%) after a converted procedure and 22.4% (19.5-25.2%) after an open procedure. Major complications (95% CI) occurred after 31.6% (23.1-40.2%) of the laparoscopically completed operations, and 46.4% (39.4-53.5%) and 49.5% (46.0-52.9%) after converted and initially open operations ( $p = 0.0012$ ), respectively. LOS (median (95% CI)) in patients not dead within 30 days post-operatively was eight (5-9) days in the laparoscopic group, 12 (11-14) days in the converted group and 11 (10-12) days in the group of initially open operations.

## DISCUSSION

We found a relatively low rate of complications following an initial laparoscopic approach and a high conversion rate to open surgery.

Two patients (0.64%) had an iatrogenic injury due to Veress needle introduction, representing the only complications directly associated with the laparoscopic approach. The Veress needle was used to create pneumoperitoneum in 31% of the patients (minimum). Creation of pneumoperitoneum is generally assumed safe. However, in a review including both elective and emergency surgery, an injury rate of 0.23% was found when Veress needle was used. Of these, 3.7% were considered major injuries [17]. Whether the safety in the

creation of pneumoperitoneum could be increased by using open access technique is debatable, and no data exist to support a strategy of only using, e.g., open Hasson technique in all cases of emergency laparoscopy [18].

Evaluating the risk of intraoperative bowel perforation is difficult, as unintended enterotomies may represent an intrinsic risk when dissecting dense adhesions; the risk may exist in both major acute open and laparoscopic abdominal surgery. In a previous study including 9,292 unselected patients undergoing emergency or elective abdominal surgery, 2% had an iatrogenic injury, with most injuries occurring during the dissection (61%) and involving the small or large bowel (48%), and most iatrogenic injuries occurring during dissection of adhesions in reoperation cases [19]. In a study of 540 unselected emergency laparoscopies primarily for appendicitis, cholecystitis or unspecific pain, four patients had an iatrogenic injury; in one of these patients, the injury was not discovered intraoperatively [3]. In two studies including patients with SBO, the rate of iatrogenic bowel injury during laparoscopy was 8.4% and 6.6%, respectively, of which one injury was not discovered intraoperatively [4, 5]. The majority of the unintended enterotomies in our study were detected intraoperatively. They occurred in 11 (3.5%) of the laparoscopically initiated operations and six of the unintended enterotomies



were related to laparoscopic instruments. Unintended injuries were the cause of conversion in 14 of 313 procedures, corresponding to 7% of the conversions.

The conversion rate in other studies of laparoscopic abdominal emergency surgery varied from 0.16% to 55%, depending on the studies' inclusion criteria. Studies in which cholecystectomies and appendectomies are included generally have a low conversion rate compared with studies including only perforated peptic ulcer or SBO [1, 3-5, 10, 13, 14]. In our study, the high 60% conversion rate reflects the patient material, but this probably constitutes a realistic estimate in a high-risk population.

We found that 14% had a surgical complication in the laparoscopically completed group, and in the converted group the surgical complication rate was 19%. Previous studies have reported complication rates in laparoscopically completed operations for SBO in the 8-31% range, and 24% in converted operations [5, 9]. In a study of patients with perforated ulcer, the complication rate was 20% in the laparoscopically completed group and 30% in the converted group [11].

One of the obvious benefits of laparoscopy is the reduction of surgical stress and wound dehiscence. Hence, dehiscence appeared only in the open/converted group in our study (6.0% in the converted group and 6.5% in the open group), which significantly reduced the risk for developing incisional hernia.

The rate of complications, LOS and mortality after laparoscopically completed procedures in our study was lower than in initially open operations, as has also been found in previous studies [5, 9-11, 14]. As in other studies of laparoscopy in high-risk emergency surgery, assessment of the benefits in an initially laparoscopic approach is severely limited by confounding by indication. A further limitation of the present study is the exclusion of solely diagnostic laparoscopies/laparotomies, which probably leads to an underestimation of the benefits of an initially laparoscopic approach in abdominal emergencies. A formal randomized clinical trial of laparoscopy versus open surgery in high-risk emergency surgery will be difficult to execute [20]; and until formal randomized trials exist in this area, the role of laparoscopy in abdominal emergencies must be based on non-randomized cohort studies.

As this study is a population-based, high-volume study with standardized registration and a 100% follow-up, it represents a best estimate of the safety and efficiency of an initially laparoscopic approach in an unselected high-risk group of abdominal emergencies.

## CONCLUSIONS

In a large cohort of abdominal emergency patients, approximately 10% could be operated with a laparoscop-

ically completed procedure. Few patients had complications specifically caused by an initially laparoscopic approach.

In an era where most surgeons are almost exclusively trained in laparoscopic technique in elective surgical care, an initially laparoscopic approach will probably gain ground as the "go-to-procedure"; also in abdominal emergencies for most surgeons.

Our study presents evidence for the use of an initially laparoscopic approach in abdominal emergency patients even if some risk of bias is present. In the absence of definitive studies, the benefits of a laparoscopic approach should befall to at least a minority of these patients.

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