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Is laparoscopy a safe approach for diffuse appendicular peritonitis? Feasibility and determination of risk factors for post-operative intra-abdominal abscess

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Abstract
Background Several studies have assessed feasibility and early outcomes of the laparoscopic approach for complicated appendicitis (CA). However, these studies suffer from limitations due to the heterogeneous definitions used for CA. No studies have assessed feasibility and early post-operative outcomes of the laparoscopic approach in the specific management of diffuse appendicular peritonitis (DAP). Consequently, outcomes of the laparoscopic approach for the management of DAP are poorly documented.
Methods The laparoscopic approach is the first-line standardised procedure used by our team for the management of DAP. All patients (aged >16 years) who underwent laparoscopy for DAP (CA with the presence of purulent fluid with or without fibrin membranes in at least a hemi abdomen) between 2004 and 2012 were prospectively included. Post-operative outcomes were analysed according to the Clavien–Dindo classification.
Results Laparoscopy for DAP was performed for 141 patients. Mean age was 39.6 ± 20 (16–92) years. A total of 45 patients (31.9 %) had pre-operative contracture. The mean pre-operative leukocyte count was 14,900 ± 4,380 mm^{-3}. The mean pre-operative C-reactive protein (CRP) serum concentration was 135 ± 112 (2–418) mg/dl. The conversion rate was 3.5 %. The mean operative time was 80 ± 27 (20–180) min. There were no deaths. The rate of grade III morbidity was 6.5 %. Ten patients (7.1 %) experienced intra-abdominal abscess (IAA); seven of these cases were treated conservatively. The mean length of hospital stay was 6.9 ± 5 (2–36) days. A pre-operative leukocyte count >17,000 mm^{-3}, and CRP serum concentration >200 mg/dl were significant predictive factors for IAA in multivariate analyses [odds ratio (OR) 25.0, 95 % confidence interval (CI) 2.4–250, $p = 0.007$ and OR 16.4, 95 % CI 1.6–166, $p = 0.02$, respectively].
Conclusion The laparoscopic approach for DAP is a safe and feasible procedure with a low conversion rate and an acceptable rate of IAA in view of the severity of the disease. Pre-operative leukocyte counts >17,000 mm^{-3} and pre-operative CRP serum concentrations >200 mg/dl indicate a high risk of IAA.

Keywords Appendicitis · Peritonitis · Laparoscopic · Intra-abdominal abscess

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About 71,245 patients underwent surgery for acute appendicitis (AA) in France in 2012 [1]; 38 % presented with a complicated disease defined as localised (27 %) or diffuse (11 %) peritonitis. The vast majority of these patients (84 % for uncomplicated appendicitis [UA] and 75 % for complicated appendicitis [CA]) were operated on via a laparoscopic approach. A European multicentre observational study over the same period reported that

30 % of AA patients presented with diffuse appendicular peritonitis (DAP) and only 49 % of these patients were treated via a laparoscopic approach [2]. This suggests heterogeneity in surgical approaches and indicates that laparoscopic surgery has not become the standard approach to the management of CA.

The first description of laparoscopic appendectomy was published by Semm [3] in 1983, and this approach was rapidly accepted as an adequate option for UA. However, initial reports of a laparoscopic approach in CA described a conversion rate of 25 % [4] and a higher rate of post-operative intra-abdominal abscess (IAA) (26 %) than with the conventional open approach (OA) [5].

Recently, a retrospective observational study [6] and a meta-analysis of retrospective case control studies [7], in contradiction with previous reports, suggested that the laparoscopic approach was more effective than the OA for the management of CA, with lower morbidity [6] and lower rates of surgical site infection [7] with no higher risk of IAA. In a large recent retrospective study of CA operated on via a laparoscopic approach, Asarias et al. [8] found a rate of IAA of 5.9 %. IAA increases the length of hospital stay and may lead to re-operation, therefore, the prevention and management of IAA remain significant challenges. Twenty years later, the laparoscopic experience has increased such that updated trials evaluating the laparoscopic approach for CA are warranted.

However, in these recent studies, the term 'CA' is used for a broad and heterogeneous spectrum of anatomo-clinical conditions (appendix gangrenous and/or perforated, localized or diffuse peritonitis). The post-operative courses of these different situations, and especially DAP—which is the most severe form of CA—could differ substantially.

No study has specifically assessed early post-operative outcomes following the management of DAP with a laparoscopic approach. The purpose of this study was therefore to assess the feasibility and early post-operative outcomes of DAP management with a laparoscopic approach and to determine risk factors for post-operative IAA.

Methods

From January 2004 to December 2012, 141 patients (16 years old or older) underwent a laparoscopic approach for DAP. No patients with DAP had OA as first intention. To identify DAP clearly among cases of CA, we used a strict per-operative definition for DAP: perforated or gangrenous appendicitis with the presence of purulent collections with or without fibrin membranes in at least a hemi-abdomen (necessarily including the pelvis, peri-appendicular and right diaphragmatic areas).

We conducted a retrospective chart review of a prospective database registered with the French national data protection agency (the Commission nationale de l'informatique et des libertés [CNIL], N°1693525) as required by law to ensure patient welfare and correct ethical behaviour. The data collected included pre-operative factors (age, sex, duration of symptoms, clinical exam findings, radiological results and laboratory values), per-operative factors (length of procedure, conversion to OA, number of drains, peritoneal cavity irrigation, method used for stump ligation) and post-operative factors (length of hospital stay, mortality, rehospitalisation and all post-operative events during the 30 days following the intervention). C-reactive protein (CRP) testing is not routinely conducted in emergency situations; consequently, these data are missing for 27 patients.

Patients were operated on by a single team in a tertiary care centre. Since 2000, our team has used laparoscopy as the first intention approach for all cases of AA (UA and CA). A standardised operative technique was used for all patients with DAP: it involved an umbilical OA to establish the pneumoperitoneum. In addition to the 10-mm optical trocar, two trocars were used: 5 mm in the suprapubic position and 5 or 10 mm in the left mid-abdomen. A 5-mm supplementary trocar was placed, if required, in the right upper quadrant of the abdomen to facilitate per-operative intra-peritoneal irrigation with saline. The base of the appendix was closed with an Endoloop® (Ethicon, Endo-Surgery, Inc.) or with a linear stapler in cases of inflamed or necrotized caecum. Bacteriological samples were collected from all cases. Peritoneal toilet with saline serum lavage or compress was systematic to obtain a clear abdominal cavity at the end of the operation. All specimens were retrieved using a bag and sent for anatomo-pathological examination. Closed-suction drains were used at the individual surgeon's discretion. Antibiotic treatment (amoxicillin/clavulanic acid or fluoroquinolone with metronidazol in cases of allergy) was started at anaesthesia induction and continued for 5 days for all patients. Thereafter, antibiotherapy was adapted to antibiogram results as appropriate. All patients with abnormal post-operative courses underwent a computed tomography (CT) scan to diagnose IAA. Depending on the size and localisation of the IAA on CT scan, antibiotic treatment (abscess <5 cm) or percutaneous/surgical drainage (abscess >5 cm) was used.

Post-operative complications were graded according to the Clavien–Dindo classification [9].

The XLSTAT® 2013 program (Addinsoft®, New York, NY, USA) for Windows was used for statistical analysis. Nominal variables are presented as percentages, and continuous data are reported as mean ± standard errors of the mean. Since risk factors for IAA in cases of DAP have

never been previously studied, we selected the third quartile values of CRP concentrations and leukocyte counts as cut-off values. We used χ^2 tests and Fisher exact tests for categorical variables as appropriate. For numerical variables, Student's *t*-tests were performed. To assess risk factors for IAA, univariate and multivariate logistic regressions were performed, including age, sex and all factors with a *p* value <0.2 in univariate analyses. The significance threshold was set at $p = 0.05$.

Results

Between 2004 and 2012, a total of 900 laparoscopic appendectomies were performed and 141 (15.7 %) patients had a per-operative diagnosis of DAP.

Mean age at time of operation was 39.6 ± 20 (16–92) years; 44.0 % were women. Contracture and fever >38 °C were present in 45 (31.9 %) and 83 (58.9 %) patients, respectively. Pre-operative radiological investigations confirmed the diagnosis of appendicitis for 135 patients (95.7 %; 130 CT scans and five abdominal ultrasound scans). The mean leukocyte count was 14,900 ± 4,380 mm^{-3} (3,400–38,000). The mean CRP concentration (available for 114 patients) was 135 ± 112 mg/dl (2–418) (Table 1). Third quartiles for leukocyte counts and serum CRP concentrations were 17,000 mm^{-3} and 200 mg/dl, respectively.

Five (3.5 %) patients required a conversion to an open procedure (one for morbid obesity, two for extensive inflammatory adhesions and two for reasons associated with anaesthesia). A total of 19 (13.5 %) patients underwent linear stapler resection of the caecum. Closed-suction drains were used in 124 patients (87.9 %); the mean operative time was 80 ± 27 (20–180) min, and mean length of hospital stay was 6.9 ± 5 (2–36) days.

According to the Clavien–Dindo classification [9], nine patients (6.5 %) had grade III and two (1.4 %) had grade IV complications. Ten (7.1 %) patients experienced post-operative IAA; seven of these cases did not require reoperation, and the initial treatment for IAA was successful in all cases. Details of post-operative complications (IIA and Clavien–Dindo grade ≥III) are listed in Table 2. There were no deaths. The 30-day readmission rate was 4.3 % ($N = 6$).

Univariate analyses and multivariate analyses identified only leukocyte count >17,000 mm^{-3} (odds ratio [OR] 25.0, 95 % confidence interval [CI] 2.4–250, $p = 0.007$) and serum CRP concentration >200 mg/dl (OR 16.4, 95 % CI 1.6–166, $p = 0.02$) as predictive factors for post-operative IAA (Table 3).

Discussion

Since the first description by Semm [3] in 1983, the laparoscopic approach has been increasingly used for AA. The initial reports concerning the laparoscopic approach for CA or UA gave poor results, with higher post-operative morbidity, particularly a higher risk of post-operative IAA [4, 5, 10, 11] than open appendectomies. Despite these poor results and because of its theoretical advantages, the use of the laparoscopic approach for AA has continued to increase and it is now widely performed [2, 12]. Recent observational or

Table 1 Patient characteristics and operative factors

Characteristics	All patients ($N = 141$)	No post-operative IAA ($N = 131$)	Post-operative IAA ($N = 10$)	*p* value*
Female (%)	62 (44.0 %)	60 (45.8 %)	2 (20.0 %)	0.11
Age (years)	39.6 ± 20 (16–92)	41 ± 19.7 (16–92)	39.6 ± 15 (20–71)	0.57
Symptom duration (days)	2.3 ± 2 (1–15)	2.3 ± 2 (1–15)	2.4 ± 1.7 (1–7)	0.44
Fever >38 °C	83 (58.9 %)	76 (58.0 %)	7 (70.0 %)	0.46
Contracture	45 (31.9 %)	41 (31.3 %)	4 (40.0 %)	0.57
Leukocyte counts (mm^{-3})	14,900 ± 4,380 (3,400–38,000)	14,500 ± 3,900 (3,400–25,000)	19,700 ± 7,300 (11,000–38,000)	0.01
CRP (mg/dl)[a]	135 ± 112 (2–418)	129 ± 107 (2–418)	204 ± 151 (13–385)	0.03
Caecal resection	19 (13.5 %)	17 (13.0 %)	2 (20.0 %)	0.53
Peritoneal irrigation with saline	121 (85.8 %)	112 (85.5 %)	9 (90.0 %)	0.70
Drainage	124 (87.9 %)	114 (87.0 %)	10 (100.0 %)	0.26

Values are mean ± SD (range) or numbers (%), as appropriate

CRP C-reactive protein, *IAA* intra-abdominal abscess, *SD* standard deviation

* *p* values for the comparison between the two groups, calculated with Student's *t* test, Chi squared tests or Fisher exact tests as appropriate

[a] $N = 114$ patients with CRP testing performed pre-operatively

Table 2 Post-operative major complications

Complications	Treatment	Grade according to Clavien et al. [9]	Patients with DAP ($N = 141$)
Post-operative IAA	Medical treatment	II	3 (2 %)
	CT scan-guided drainage	IIIa	4 (3 %)
	Laparoscopic surgical drainage	IIIb	2 (1.4 %)
	Open surgical drainage	IIIb	1 (0.7 %)
Haemorrhage at the stapler line	Laparoscopic ileo-caecal resection	IIIb	1 (0.7 %)
Aseptic pleuresia	Pleural drainage	IIIa	1 (0.7 %)
Septic shock	ICU	IV	1 (0.7 %)
Ventricular right failure on congenital cardiomyopathy	ICU	IV	1 (0.7 %)
Mortality	NA	V	0
30-day re-admission	NA	NA	6 (2.4 %)

Data are presented as *N* (%)

CT computed tomography, *DAP* diffuse appendicular peritonitis, *IAA* intra-abdominal abscess, *ICU* intensive care unit, *NA* not applicable

randomised studies indicate significant benefits for the laparoscopic approach compared with the OA for UA [6, 13, 14] and also for CA [6, 7, 15, 16] in terms of length of hospital stay, morbidity and wound abscess.

In most studies, AA is divided into two groups: UA and CA. However, the reported series assessing the laparoscopic approach for CA uses heterogeneous definitions of CA; it has been defined according to per-operative status (gangrenous/perforated appendicitis with one abscess [17] or with/without localised/diffuse peritonitis [15, 18–20]) or histological findings (gangrenous or perforated appendicitis with histological peritonitis) irrespective of per-operative reports [21–24] and according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) of a health system database (codes 540.0 and 540.01: perforated appendicitis) [6]. Some series excluded DAP from their analysis [25, 26] and there is no consensus definition for DAP in the literature. Only Navez et al. [4] reported outcomes of the laparoscopic approach for DAP (gangrenous/perforated appendicitis with purulent fluid in two or more quadrants of the abdomen). However, this study suffers from limitations: a small cohort ($N = 32$), a high conversion rate (25 %) and use of 'reverse laparoscopy' (conversion of a McBurney incision to a laparoscopic approach).

In our study, we used a strict peri-operative definition, consequently excluding from our sample patients with localised peritonitis (pus either in the peri-appendicular area or in the sac of Douglas) as reported in other series [4, 18, 25, 27].

As our paper is, to our knowledge, the first report of a large study of DAP treated with a laparoscopic approach, comparison with previous studies is difficult. The pre-operative characteristics of patients are more severe than in previous reports evaluating CA [28, 29].

The low rate of conversion in our experience is comparable to published values. In the literature, reported conversion rates after a laparoscopic approach for CA varies from 1.7 to 39 % [21]. Our mean operative time is longer than that reported by Cueto et al. [27] with their experience in 1,017 CA cases. This difference is probably due to the time required for peritoneal lavage and insertion of drainage. There is no consensus on the necessity for lavage and drainage after appendectomies for CA. Allemann et al. [25] do not recommend routine drainage in a laparoscopic approach for CA. St Peter et al. [30] found no advantage for irrigation of the peritoneal cavity over suction alone during LA for perforated appendicitis in children. However, these studies excluded cases of DAP, and as peritoneal lavage and drainage were not found by univariate analysis to be risk factors for IAA in our study, we still recommend their use.

CA is a risk factor for increased post-operative morbidity [6, 8, 31] and (according to Asarias et al. [8]) for IAA with an OR of 6.1 (95 % CI 3.4–11.1, $p < 0.01$). The rate of IAA in our series of 141 DAP (excluding all other CA) was 7.2 %. No other study has reported or assessed risk factors for IAA after a laparoscopic approach with DAP. In the literature, the reported rates of IAA for all types of CA vary from 2.8 to 14 % [8, 15, 16, 20, 27]. The limitations of our study include that it was a retrospective review of a prospective database, and the large CI for our OR could be explained by the rarity of IAA in our study population. Multivariate analyses identified pre-operative leukocyte counts >17,000 mm^{-3} and serum CRP concentrations >200 mg/dl as significant predictive risk factors for IAA. This suggests that surgeons should be warned about the risk of IAA after a laparoscopic approach for DAP in patients presenting with values above these cut-offs.

Occurrence of IAA often requires intravenous antibiotherapy and lengthens the hospital stay. Hence, the mean length of stay of our patients was higher than that in other large previous studies of CA [6, 27]. However, with reference to other studies assessing only CA, our results, including a low conversion rate, and acceptable grade III

Table 3 Univariate and multivariate analyses of baseline characteristics and of operative factors associated with post-operative IAA

	Univariate analyses			Multivariate analyses		
	OR	95 % CI	*p* value	OR	95 % CI	*p* value
Female versus male	0.3	0.1–1.4	0.13	0.08	0.007–1.05	0.06
Age (years)	1.0	0.97–1.03	1.00	1.0	0.94–1.03	0.57
Symptom duration (days)	1.0	0.7–1.3	0.90			
Fever >38 °C	0.6	0.1–2.4	0.46			
Contracture	1.0	0.36–2.9	0.97			
Leukocyte count >17,000 mm^{-3}	14.1	2.8–71.4	0.001	25.0	2.4–250	0.007
CRP >200 mg/dl[a]	4.5	1.1–17.9	0.04	16.4	1.6–166	0.02
Caecal resection	0.6	0.1–3.0	0.53			
Peritoneal irrigation with saline	1.5	0.2–12.7	0.70			
Drainage	2.3	0.2–21.6	0.47			

CI confidence interval, *CRP* C-reactive protein, *IAA* intra-abdominal abscess, *OR* odds ratio

[a] $N = 114$ patients with CRP testing performed pre-operatively

complication and IAA rates, suggest that the laparoscopic approach for DAP is feasible and safe.

Conclusion

Our study assessed the feasibility and safety of the laparoscopic approach for DAP and we recommend it in these situations. Surgeons and patients should be aware of the risk of post-operative IAA if the pre-operative leukocyte count is higher than 17,000 mm^{-3} and/or the serum CRP concentration is >200 mg/dl. Prospective randomized studies are needed for rigorous comparison of the laparoscopic approach and the OA for the management of DAP.

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