Risk factors for intraabdominal abscess formation after laparoscopic appendectomy – results from the Pol-LA (Polish Laparoscopic Appendectomy) multicenter large cohort study

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Abstract

Introduction: *According to meta-analyses laparoscopic appendectomy is associated with many benefits. However, in comparison to open surgery an increased rate of intraabdominal abscesses (IAA) has been reported. Identification of predictive factors for this complication may help to identify patients with higher risk of IAA.*
Aim: *To identify potential risk factors for intraabdominal abscess after laparoscopic appendectomy (LA).*
Material and methods: *Eighteen surgical units in Poland and Germany submitted data of patients undergoing LA to the online web-based database created by the Polish Videosurgery Society of the Association of Polish Surgeons. It comprised 31 elements related to the pre-, intra- and postoperative period. Surgical outcomes were compared among the groups according to occurrence of IAA. Univariate and multivariate logistic regression models were used to identify potential risk factors for IAA.*
Results: *4618 patients were included in the analysis. IAA were found in 51 (1.10%) cases. Although several risk factors were found in univariate analysis, in the multivariate model, only the presence of complicated appendicitis was statistically significant (OR = 2.98, 95% CI: 1.11–8.04). Moreover, IAA has a significant influence on postoperative reintervention rate (OR = 126.95, 95% CI: 67.98–237.06), prolonged length of stay > 8 days (OR = 41.32, 95% CI: 22.86–74.72) and readmission rate (OR = 33.89, 95% CI: 18.60–34.73).*
Conclusions: *Intraabdominal abscesses occurs relatively rarely after LA. It is strongly associated with complicated appendicitis. Occurrence of this complication has a great influence on the postoperative period and due to the nature of its treatment is associated with the need for reintervention, prolonged length of stay and by extension possible readmission.*

Key words: *laparoscopic appendectomy, acute appendicitis, complications, intraabdominal abscess, complicated appendicitis.*

Introduction

As the most common cause of sudden abdominal pain requiring surgery, acute appendicitis is frequently seen in emergency departments. According to collected data from the USA, the overall lifetime risk of acute appendicitis is approximately 8% [1].

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Thus, appendectomies are among the abdominal procedures most frequently performed by general surgeons. Since the first successful laparoscopic appendectomy (LA) was performed in 1983 [2], this minimally invasive approach has gradually become the preferred operative technique for acute appendicitis [3]. Laparoscopic appendectomy in comparison to open appendectomies presented major advantages: a lower incidence of postoperative wound infections, pain reduction, and shorter length of hospital stay (LOS) [4–6]. Moreover, LAs are associated with an earlier return to normal activity [1]. The drawback of minimally invasive access is an increased incidence of intraabdominal abscess (IAA) formation after LA [1]. It is associated with higher morbidity and increased LOS. The majority of patients who develop IAA require therapeutic intervention, starting with conservative antibiotic treatment, percutaneous drainage, or reoperation. Previous studies have shown some risk factors of developing IAA; however, the limited data on the risk of IAA specifically after laparoscopic procedures call for further analysis. Moreover, the identification of risk factors for IAA formation may allow doctors to select patients prone to this complication and take preventative measures. Based on a large cohort of patients, we aimed to establish both the incidence and the possible risk factors for the development of IAA after LA for appendicitis. Additionally, we evaluated the influence of IAA formation on patients' postoperative outcomes.

Aim

This study aims to identify potential risk factors for IAA after LA and determine LA influence on postoperative outcomes.

Material and methods

This multicenter study was performed across 18 surgical centers in both Poland and Germany over a 6-month period. The data collected from patients admitted for laparoscopic appendectomy were assembled in an internet-based database. The design and implementation of this study followed the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [7]. This study includes both retrospective data from previous patients at each center and data from patients enrolled during the study period. Data acquisition was performed by the coordinating surgeon and the local team of nurses, anesthesiologists, and assistants. The database recorded the following variables from each center: annual number of laparoscopic appendectomies performed, patient characteristics (sex, age, body mass index (BMI), ASA score, history of smoking, diabetes mellitus, timing from onset of symptoms to surgery, Alvarado score), white blood cell count (WBC), C-reactive protein level (CRP), operative parameters (operative time, type of surgeon performing the appendectomy (resident/specialist), type of AA (uncomplicated/complicated), intraoperative adverse events, and postoperative outcomes (postoperative morbidity, need for surgical reintervention, LOS, need for readmission).

The study and control groups were divided based on the presence of IAA development in the postoperative period. Complicated AA was diagnosed based on imaging diagnostics and/or visualization during relaparoscopy/relaparotomy performed due to the patient's condition.

This study did not implement any changes in patient treatment. A primary investigator monitored this study. He processed and verified any missing or unclear data submitted to the database. The data collected were anonymized and had no identifying patient information. The only hospital data included were the number of laparoscopic appendectomies performed annually. The study did not need informed consent or formal approval by a local ethics committee due to the observational nature. The project was supported by the Polish Videosurgery Society – a chapter of the Association of Polish Surgeons.

Statistical analysis

Statistical analyses were done using StatSoft Statistica 13.0 PL (StatSoft Inc., Tulsa, Oklahoma, USA). Continuous variables were presented using means with standard deviations (SD) or medians with inter-quartile ranges (IQR) for skewed variables. Then, comparisons between groups were done using Student's *t* test for normally distributed variables and the Mann-Whitney test for skewed variables. Dichotomous variables were included in χ^2 Pearson's, Yates' and Fisher's exact tests, depending on the quantities in the subgroups. Finally, univariate and multivariate logistic regression models were built to determine risk factors for postoperative complications. Results were considered statistically significant when *p*-values were < 0.05. In the case of missing data, pairwise deletion was used.

Results

This study includes data from 4618 patients. Characteristics of the study group are presented in Table I. The majority of patients (3269/4618 70.79%) underwent LAs in centers performing over 50 LAs per year. 2034 (44.05%) patients were operated on by surgical residents under the supervision of an attending surgeon. 2409 (52.2%) patients were male and 2209 (47.8%) were female. Median age of the entire study group was 33 years (IQR: 24–47). Median BMI was 24.8 kg/m^2 (IQR: 22.03–28.5). 794 (19.19%) patients were active smokers and 147 (3.18%) had diabetes mellitus. Concerning the ASA physical status classification system, 3214 (69.60%) patients were classified as ASA class I, 1213 (26.27%) ASA class II, 184 (3.98%) ASA class III, and 7 (0.15%) ASA class IV. 1463 (31.68%) patients complained of symptoms of AA > 48 h before surgery. Median WBC was 13.1 × 1000 per mm^3 (IQR: 10.04–16.1) and CRP was 27.3 mg/l (6.2–72).

Fifty-one (1.10%) patients developed IAA in the postoperative period. Groups differed in almost all analyzed parameters. Full preoperative characteristics of these two groups are presented in Table I.

Operative parameters for both groups are presented in Table II. Median operative time was longer in the IAA group (70 vs. 54 min, *p* = 0.001). Patients with eventual IAA formation had a higher incidence of complicated appendicitis (36/51 (71%) vs. 1233/3334 (27%), *p* < 0.001). Intraoperative periappendiceal abscesses were found in 24 (47.05%) patients in the IAA group and in 534 (11.7%) patients in the non-IAA group (*p* < 0.001). Intraoperative adverse events occurred in 5 (9.8%) patients in the IAA group and in 99 (2.17%) patients in the non-IAA group (*p* = 0.001). Drains were left in the peritoneal cavity in 48 (94%) patients in the IAA group and in 3444 (75.41%) patients in the non-IAA group (*p* = 0.004).

Table I. Baseline characteristics of study groups

Parameter	Intraabdominal abscess	No abscess	*P*-value
N (%)	51 (1.10)	4567 (98.90)	N/A
Males/females (%)	35/16 (68.63%/31.37%)	2374/2193 (51.98%/48.02%)	0.026
Age, median (IQR) [years]	37 (29–47)	32 (24–47)	0.043
BMI, median (IQR) [kg/m^2]	26.25 (23.75–29.4)	24.8 (22–28.5)	0.148
ASA class:			
IV	0 (0.0%)	7 (0.16%)	0.708
III	4 (7.84%)	180 (3.94%)	
II	15 (29.41%)	1198 (26.24%)	
I	32 (62.75%)	3182 (69.66%)	
Smoking	9 (18.60%)	785 (17.19%)	0.805
Diabetes mellitus	5 (10%)	142 (3.11%)	0.019
Symptoms > 48 h	27 (53%)	1436 (31.44%)	0.001
Median Alvarado score (IQR)	7 (6–8)	6 (4–8)	0.021
Alvarado ≥ 7	32 (61.90%)	1982 (43.39%)	0.016
Leukocytosis, Median (IQR) [× 1000 per mm^3]	14.9 (13.2–17.98)	13.04 (10–16.1)	0.001
CRP, median (IQR) [mg/l]	92.05 (37.22–224.78)	27 (6.1–71.28)	< 0.001
CRP > 100	25 (50%)	802 (17.55%)	< 0.001

Table II. Operative parameters and postoperative outcomes in studied groups

Parameter	Intraabdominal abscess	No abscess	*P*-value
No. of appendectomies/year in department:			
> 50	41 (80.39%)	3228 (70.68%)	0.173
< 50	10 (19.61%)	1339 (29.32%)	
Residents vs. specialists	26/25 (51%/49%)	2008/2559 (44%/56%)	0.309
Operative time, median (IQR) [min]	70 (50–90)	54 (40–70)	0.001
Complicated vs. uncomplicated appendicitis	36/15 (71%)	1233/3334 (27%)	< 0.001
Intraoperative periappendiceal abscess	24 (47.05%)	534 (11.7%)	< 0.001
Intraoperative diagnosis:			< 0.001
Unchanged appendix	0 (0.0%)	372 (8.14%)	
Purulent appendicitis	18 (35.29%)	3142 (68.98%)	
Gangrenous appendicitis	20 (39.22%)	846 (18.57%)	
Perforated/autoamputated appendix	13 (25.49%)	196 (4.31%)	
Intraoperative adverse events	5 (9.80%)	99 (2.17%)	0.001
Postoperative drainage	48 (94%)	3444 (75.41%)	0.004
Conversions	4 (7.84%)	290 (6.35%)	0.883
Reinterventions after primary procedure	33 (64.71%)	65 (1.42%)	< 0.001
LOS, median (IQR)	9 (4–13)	3 (2–4)	< 0.001
LOS > 8 days	33 (64.71%)	661 (14.48%)	< 0.001
Readmissions	21 (41.18%)	95 (2.08%)	< 0.001

Overall, 33 (64.71%) patients with IAA and 65 (1.42%) without an IAA required reintervention after the primary procedure ($p < 0.001$). Out of them 3 (5.88%) patients underwent percutaneous drainage of the abscess and 30 (58.82%) required another surgery. Of the cases necessitating other surgical interventions, 14 (27.45%) had a relaparotomy, 11 (21.56%) had a relaparoscopy with 1 case of conversion, and in 5 (9.80%) cases there was no information whether reintervention was open or laparoscopic. Eighteen (35.29%) patients were treated conservatively with antibiotics.

Median LOS was longer in the IAA group (9 (IQR: 4–13) vs. 3 (IQR: 2–4) days, $p = 0.001$). Thirty-three (64.71%) patients in the IAA group and 194 (14.48%) patients in the non-IAA group needed to spend longer than 8 days (longer than 2* third quartile) in the hospital. Patients with IAA were readmitted more frequently compared to those with no abscess formation (21 (41%) vs. 89 (2.08%), $p < 0.001$).

The results of the univariate analysis of IAA risk factors utilizing pre- and perioperative parameters are shown in Table III. The following parameters were associated with the formation of IAA: male sex (OR = 2.02, 95% CI: 1.11–3.66), age > 35 years (OR = 1.93, 95% CI: 1.10–3.37), diabetes mellitus (OR = 3.46, 95% CI: 1.35–8.87), time from onset of symptoms to LA > 48 h (OR = 2.47, 95% CI: 1.40–4.34), Alvarado scale (OR = 1.15, 95% CI: 1.01–1.31 with every point higher), CRP > 50 mg/l (OR = 3.96, 95% CI: 2.09–7.49), complicated appendicitis, i.e. perforated/gangrenous or with periappendiceal abscess (OR = 6.49, 95% CI: 3.54–11.90), gangrenous appendicitis (OR = 2.48, 95% CI: 1.61–5.00), perforated/autoamputated appendix (OR = 7.63, 95% CI: 4.00–14.56) intraoperative adverse events (OR = 4.89, 95% CI: 1.90–12.58). In turn, purulent appendicitis was found to lower the risk of IAA (OR = 0.25, 95% CI: 0.14–0.44).

Table III. Risk factors for postoperative intraabdominal abscess

Parameter	OR	95% CI	*P*-value
Univariate analysis:			
Male	2.02	1.11–3.66	0.020
Age > 35 years	1.93	1.10–3.37	0.022
Obesity	1.31	0.56–3.05	0.531
ASA class	1.27	0.77–2.09	0.346
Smoking	1.10	0.50–2.41	0.807
Diabetes mellitus	3.46	1.35–8.87	0.010
Symptoms > 48 h	2.47	1.40–4.34	0.002
With every point of Alvarado grading higher	1.15	1.01–1.31	0.032
Alvarado ≥ 7	2.12	1.13–3.97	0.019
CRP > 100 mg/l	4.70	2.58–8.54	< 0.001
> 50 appendectomies/year in department	1.70	0.85–3.41	0.135
Residents vs. specialists	0.75	0.43–1.31	0.312
Purulent appendicitis	0.25	0.14–0.44	< 0.001
Gangrenous appendicitis	2.84	1.61–5.00	< 0.001
Perforated/autoamputated appendix	7.63	4.00–14.56	< 0.001
Intraoperatively diagnosed periappendiceal abscess	6.51	3.69–11.49	< 0.001
Complicated appendicitis	6.49	3.54–11.90	< 0.001
Drainage	5.11	1.58–16.49	0.006
Conversions	1.26	0.45–3.51	0.664
Multivariate analysis:			
Male	0.68	0.33–1.39	0.289
Age > 35 years	0.92	0.43–1.95	0.827
Diabetes mellitus	2.59	0.82–8.23	0.106
Symptoms > 48 h	1.23	0.59–1.44	0.584
Alvarado ≥ 7	1.90	0.90–4.00	0.091
CRP > 100 mg/l	1.32	0.61–2.86	0.483
Complicated appendicitis	2.98	1.10–8.04	0.031
Intraoperatively diagnosed periappendiceal abscess	1.47	0.59–3.65	0.403

In the multivariate model, only the presence of complicated appendicitis (OR = 2.98, 95% CI: 1.11–8.04) was statistically significant.

Further analysis showed that the presence of IAA has a significant influence on postoperative re-intervention (OR = 126.95, 95% CI: 67.98–237.06), prolonged length of stay > 8 days (OR = 41.32, 95% CI: 22.86–74.72) and readmission rate (OR = 33.89, 95% CI: 18.60–34.73) (Table IV).

Discussion

Based on this large volume observational study, we concluded that the development of an IAA is strongly associated with the underlying state of the appendicitis. The presence of complicated AA remained the only independent risk factor for postoperative IAA formation. We also confirmed that once IAA is diagnosed, it strongly affects postoperative outcomes, such as increased surgical reintervention rate, prolonged LOS, and higher readmission rate.

Laparoscopic appendectomy is the most commonly used surgical intervention for AA, with more than 50% of cases being treated in this manner in developed countries [8–10]. Nevertheless, recent meta-analyses, including the most recent 2010 Cochrane systematic review, revealed a higher incidence of postoperative IAA formation after LA in comparison to OA [1]. This review was the second update of an original 2002 publication [11]. Interestingly, each update of this original publication attempts to decrease the varying rates of IAA formation between LA and OAs; the likelihood of IAA after LA was nearly threefold after an LA (OR = 2.77) in the original publication, then decreased in the first update in 2004 (OR = 2.48), and further decreased in the second update in 2010 (OR = 1.87) [1, 11, 12]. Additionally, in the recent 2016 cumulative meta-analysis, a change in treatment results was noted – the effect size in favor of open procedures began to disappear after 2001, leading to an insignificant result with an overall cumulative OR of 1.32 (95% CI: 0.84–2.10) when laparoscopic appendectomy was compared with open appendectomy [13]. This is in line with several other meta-analyses [14–16].

This study allowed us to confirm that IAA is, in fact, a rare complication. The rate of IAA formation in our cohort was 1.1%, which, while low, is still in the range reported elsewhere [17–19]. Nevertheless, since it theoretically can occur in every patient undergoing an appendectomy, the identification of potential risk factors might be helpful in postoperative follow-up of patients.

In this study group, the univariate logistic regression models revealed several risk factors for postoperative IAA: male sex, age greater than 35 years, diabetes mellitus, longer duration of symptoms, higher Alvarado score, higher WBC and CRP levels, longer operative time, intraoperative diagnosis of periappendiceal abscesses, the presence of complicated appendicitis, and postoperative drainage. In the multivariate model, however, only the presence of complicated appendicitis remained significant in the development of IAA. This supports the claim that the nature of the AA itself is the strongest of all identified factors. Trying to explain these findings, we noted that among the perioperative parameters that might contribute to IAA formation, most of them are in fact related to the clinical picture of complicated appendicitis. For instance, higher CRP, higher WBC levels, and longer duration of symptoms, which were associated with IAA formation, are also associated with complicated appendicitis. Previous studies claimed that certain patient characteristics such as older age and diabetes mellitus may contribute to IAA occurrence; however, because these factors became insignificant in the multivariate logistic regression model, they cannot be considered independent risk factors. The only independent risk factor for IAA is complicated appendicitis. However, the data on the link of complicated AA and IAA are contradictory. The analysis by Cho *et al.* found no differences between complicated and uncomplicated appendicitis in terms of IAA [19]. In contrast, Schlottmann *et al.* observed higher incidence of IAA formation in patients with a gangrenous/perforated appendix [20].

Table IV. Influence of intraabdominal abscess on postoperative outcomes

Parameter	OR	95% CI	*P*-value
Reinterventions	126.95	67.98–237.06	< 0.001
Prolonged LOS (> 8 days)	41.32	22.86–74.72	< 0.001
Readmissions	33.89	18.60–34.73	< 0.001

Several strategies have been implemented to diminish the risk of IAA. Although the rate of patients with postoperative drainage was higher in the IAA group, we do not believe that peritoneal drainage itself contributed to IAA formation. Schlottmann *et al.* confirmed that drains are more often needed in cases of complicated appendicitis [20]. In our study, peritoneal drainage, while a risk factor in the univariate analysis, became insignificant in the multivariate model. According to a recent Cochrane review and other analyses, a no-drainage policy, even in complicated appendicitis, is safe and does not increase infectious complication rates [21–23].

Once IAA occurs, it certainly impacts postoperative outcomes. Almost two thirds of patients with IAA required reintervention after surgery, in the form of either percutaneous drainage or an operation. More than 50% of patients needed another operation. It is important to note that the majority of these surgically treated patients underwent relaparoscopy; in our opinion, this is feasible in patients with IAA without symptoms of general peritonitis.

Our study does have several limitations. Firstly, the majority of patients were assessed retrospectively. Only 30-day readmission rates to hospitals were analyzed, which may have impacted our stated rate of readmissions in both the IAA and non-IAA groups. Secondly, we did not analyze perioperative care protocols and operative techniques in each hospital. Although this may have some impact, LA is relatively straightforward, and it is rather unlikely that it significantly altered the outcomes. We did not observe an increased number of IAA in any of participating centers that would have suggested widely varying protocols between hospitals. Lastly, each hospital's antimicrobial policy was also not analyzed in our database. This policy most likely did vary depending on the surgical unit. Although preoperative antibiotics have been shown to reduce complication rates, there is a lot of controversy as to whether they are of benefit in the postoperative period. The preventative effect of antibiotics in uncomplicated appendicitis is often negligible [24, 25], and, similarly, their use is being reduced in complicated cases as well [26]. Still, no good quality randomized controlled trials assess this aspect of perioperative care in complicated appendicitis.

Conclusions

Intraabdominal abscesses occurs rarely after LA and is strongly associated with complicated appendicitis. This complication greatly influences the postoperative period. Its treatment is associated with the need for reintervention, a prolonged length of stay, and possible readmission.

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Conflict of interest

The authors declare no conflict of interest.

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