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Appendectomy in Germany—an analysis of a nationwide survey 2011/2012

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Abstract

Introduction Although appendectomies are frequently performed and new procedural techniques have emerged, no nationwide analysis exists after the cessation of the German quality control in 2004.

Methods One thousand eight hundred seventy surgical hospitals in Germany were asked to answer questions anonymously concerning the size of the department, applied procedural techniques, various technical details, as well as the approach to the intraoperative finding of an inconspicuous appendix.

Results We received 643 questionnaires (34.4 %) for evaluation. Almost all hospitals (95.5 %) offer laparoscopic appendectomy (LA), 15.4 % offer single-port (SPA), and 2.2 % (hybrid-) NOTES technique (NA). LA is the standard procedure in 85.2 % of male and in 89.1 % for female patients. In an open procedure (OA), the appendix and mesoappendix are mostly ligated (93.8 and 91.5 %). A Veress needle and open access are employed equally for LA. In 66.6 % of LA, the appendix is divided using an Endo-GIA, the mesoappendix in 45.5 % with bipolar coagulation. Almost half of the hospitals routinely flush the site in OA and LA. In open surgery with an inconspicuous appendix but a pathological finding elsewhere in the abdomen, it is resected "en principe" in 64.7 % and in the absence of any pathological finding in 91.2 %. For laparoscopic procedures, the numbers are 54.8 and 88.4 %.

Conclusions Most German hospitals perform appendectomies laparoscopically regardless of patients' gender. Usage of an Endo-GIA is widely established. SPA has not gained much acceptance, nor is NA widely used yet. In the absence of any pathological findings in particular, the macroscopically inconspicuous appendix results in an appendectomy "en principe" in most German hospitals.

Keywords Survey · Appendectomy/methods · Appendicitis/ surgery · Laparoscopy/methods · Laparoscopic · Open · Single port · NOTES · Surgical technique

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Introduction

Appendectomy is one of the most frequently performed operative procedures in general surgery departments of every size and category. LA as compared to OA was very controversial at first but has found increasing acceptance in Germany. Compulsory quality control of appendectomy procedures by the Bundesgeschäftsstelle Qualitätssicherung gGmbH (BQS), the federal institute for quality and patient safety, ended in 2003. In that last year, about 40 % of all appendectomies were performed laparoscopically in Germany. No survey on this procedure has been performed since. Various meta-analyses and Cochrane reviews have compared LA with OA and different technical details. Furthermore, new surgical methods have recently emerged, namely, the single-port and NOTES

technique. Their distribution among the hospitals, however, is unclear. Using laparoscopic mini-instruments with trocars of 2–3.5 mm diameter is proposed as a reliable alternative due to less postoperative pain and improved aesthetics. How to proceed in case of an inconspicuous appendix during a procedure planned as an appendectomy remains controversial despite existing study results. Therefore, we conducted a nationwide survey on the performance of appendectomies and their technical details as well as the management of the intraoperative finding of an inconspicuous appendix.

Methods

An invitation to participate in our survey was sent via email to 1,870 heads of German general and abdominal surgical departments on August 12, 2011. The "Berufsverband Deutscher Chirurgen" (Professional Association of German Surgeons) collected the email addresses of the hospitals and conducted the mailing. The survey was conducted under the patronage of the "Chirurgische Arbeitsgemeinschaft für Minimal-Invasive Chirurgie" (Workgroup Minimal Invasiv Surgery) of the "Deutsche Gesellschaft für Allgemein- und Viszeralchirurgie" (DGAV, German Society of General and Visceral Surgery) without any financial ties.

The online questionnaire was to be completed anonymously online through a web link. The questionnaire asked for the postal code to filter out redundant data sets. An email reminder was sent to all hospitals after 6 and 10 weeks to achieve a representative return rate.

The questionnaire comprised 60 questions. Questions included the hospital category, hospital operator, number of beds of the entire hospital and of the department, as well as their specialties. General questions concerned the overall amount of appendectomies, the procedural techniques offered, and, if applicable, the preferred port in SPA and the techniques used in NA. Further questions addressed the amount of OA, LA, SPA, NA, and other appendectomies as well as the incidence of conversions from laparoscopic to open, single port to laparoscopic, single port to open, (hybrid-) NOTES to laparoscopic and (hybrid-) NOTES to open procedures in 2010. We asked to name the standard appendectomy technique (OA, LA, SPA, NA, or other) for both male and female patients and the reason given in each case (current recommendation in studies, limited human resources, limited technical resources, training procedure for the mentioned technique, or other). For OA and LA, the indication for administration of antibiotics (prophylactic antibiotics, antibiotic treatment, depending on intraoperative finding, or no antibiotics), choice of antibiotics (cephalosporins group, 1/2; cephalosporins group, 3; aminopenicillin, aminopenicillin + betalactamaseinhibitor, acylaminopenicillin + betalactamaseinhibitor, fluorochinolons group, 2/3; carbapenems,

metronidazole, or others; multiple responses possible), duration of antibiotic treatment in days, flushing of the surgical field (yes/no), amount of flushing solution (<500, 500–999, 1,000–1,499, 1,500–2,999, or ≥3,000 ml), frequency of intra-abdominal drain placement (always/mostly, rarely/never, or depending on intraoperative finding), type of intraabdominal drain (Easy-Flow, Jackson-Pratt, Blake, tube, or other) and duration of drainage, type of skin closure (subcuticular with resorbable sutures, subcuticular with nonresorbable sutures, interrupted sutures, staples, or other), average postoperative hospital stay, and management in case of inconspicuous appendix with or without a pathological finding elsewhere in the abdomen explaining the symptoms that led to the procedure (leaving the appendix in situ, appendectomy "en principe," or other) were identified. Additional questions addressed the access for OA (McBurney incision, pararectal laparotomy, or other), as well as the dividing of the appendix (tied off at its base and then divided using a scalpel, stapling device, resorbable clip, nonresorbable clip, ot other), the technique for control of the mesoappendix (ligation, stapling device, bipolar cauterization, resorbable clip, nonresorbable clip, or other), the way of inverting the appendix stump (purse string suture, Z-suture, both, or neither), placement of a subcutaneous redon drain (always/mostly, rarely/never, or depending on intraoperative finding), and subcutaneous sutures (always/mostly, rarely/never, or depending on intraoperative finding). For LA, we inquired the way to establish a capnoperitoneum (Veress needle, open access, or other), the kind of trocars (reusable or single use), number and diameter of trocars, the dividing of the appendix (endoloop with or without purse string suture/Z-suture, Endo-GIA, resorbable clip, nonresorbable clip, or other), and the technique for control of the mesoappendix (bipolar cauterization, monopolar cauterization, stapling device, resorbable clip, nonresorbable clip, or other).

Statistical analysis

Data processing and statistics of all variables were done using IBM SPSS Statistics 19. Several subgroup analyses were also conducted with that program. The chi-square test was used for nominal attributes like minimally invasive surgery (MIC) specialization and hospital operator; the chi-square test for trend was used for ordinal attributes like the amount of appendectomies per year, the category of the hospital, size of the department, and the standard procedure for female and male patients (both open, laparoscopic and open, or both laparoscopic). The McNemar's test was used to determine whether the standard approach is the same for the male and female patients. A $p < 0.05$ was considered statistically significant.

Results

We received 836 data sets, 193 of which had to be excluded due to incomplete data or identical or missing postal code. The remaining 643 data sets were analyzed. The distribution of the answering hospitals is shown in Fig. 1.

Hospitals data

Sixty-three percent of the questionnaires were answered by standard care level hospitals, 22.2 % came from mid level, 8.9 % from referral centers, and 4.8 % from university hospitals. Hospital operators were mostly nonprofit (47.3 %), 28.3 % wmunicipal, 17.3 % private, 5.3 % the state, and 0.5 % insurance companies (i.e., trade association). Of the hospitals, 25.5 % had up to 200 beds, 36.7 % had 201–400 beds, 19.1 % had 401–600 beds, 6.9 % had 601–800 beds, 4.1 % 801–1,000 beds, and 7.7 % more than 1,000 beds. The number of beds in the surgical departments is up to 40 in 30.1 %, 41–60 in 43.9 %, 61–80 in 16.1 %, 81–100 in 6.3 %, and more than 100 in 3.6 %. Of the departments, 83.0 % declare to hold a specialization in GI surgery, and 24.3 % are a center for minimally invasive surgery. Mostly, 100–149 appendectomies are carried out annually (28.6 % of hospitals). Figure 2 shows the exact distribution.

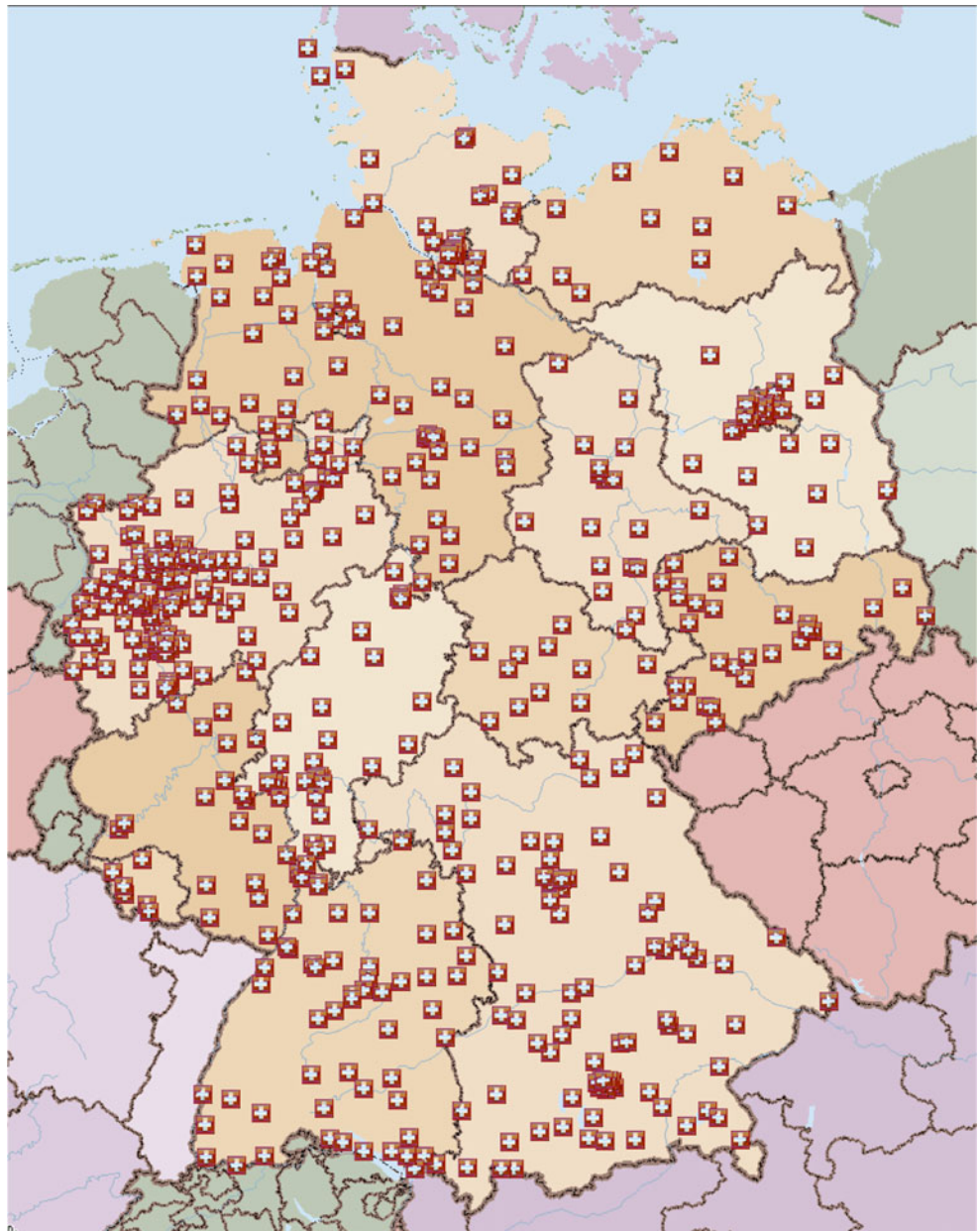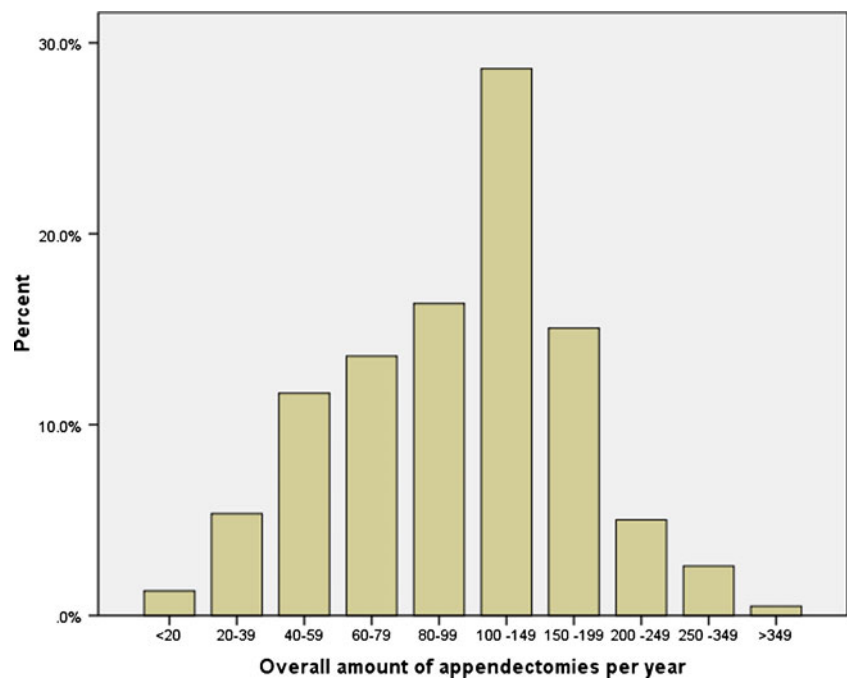**Fig. 1** Nationwide distribution of the hospitals that answered the survey

Fig. 2 Percentage of clinics that perform a certain amount of appendectomies per year

Therapy details

Of the hospitals, 73.4 % offer OA, 95.5 % LA, 15.4 % SPA, and 2.2 % NA. Additionally, 1.1 % perform mini-laparoscopic appendectomy, two hospitals (0.3 %) perform transumbilical laparoscopic appendectomy (TULAA), and one hospital (0.16 %) performs covert laparoscopic access appendectomy.

Among the hospitals performing SPA, 71 (71.7 %) use a SILS™ Port (Covidien), 22 (22.2 %) use an X-Cone™ (Karl Storz), 21 (21.2 %) use a GelPOINT® (Applied Medical), 18 (18.2 %) use a Triport™ (Olympus/ASC), and 3 (3 %) use the ECTO-Port™ (ATSmedical) (multiple votes possible).

A transvaginal pure-NOTES appendectomy is performed in 5, the transvaginal/transumbilical hybrid-NOTES technique in 13, and transgastral NOTES appendectomy in 1 hospital. Both SPA and NA are significantly more frequent in MIC centers ($p=0.003$ and $p=0.008$). Performance of NA correlates positively with increasing size of department ($p=0.001$) and higher hospital category ($p=0.046$).

Most hospitals (69.5 %) conduct <20 OA per year. The amount of LA varied broadly. Few hospitals perform more than 20 SPA; one performs more than 20 NA per year.

Only 5.6 % declared to convert 10 or more LA to conventional technique annually. Conversion from SPA to LA (no conversions in 88.7 %) or OA (no conversions in 93.1 %), and from NA to LA (no conversions in 99.2 %) or OA (no conversions in 99.1 %) are rare.

Standard procedure depending on gender

For men, the standard appendectomy technique is listed in Table 1. The reasons for the respective choice are the following: standard method is a teaching operation (38.9 %), current study results (36.4 %), limited human resources (10.6 %), and limited technical resources (2.6 %). There were a number of other answers given, some of which referred to lower costs of OA.

The standard appendectomy technique for women is also listed in Table 1. Here, the choice is made due to current study results in 41.4 %, limited human resources in 8.2 %, and limited technical resources in 2.5 %. Other reasons were improved cosmetic results, better intraabdominal view, and better gynecological diagnostic possibilities. The standard method for female patients is teaching operation in 35.9 % of the hospitals.

Table 2 shows how the hospitals use LA and OA as a standard procedure depending on the patients' gender. No hospital has the standard of laparoscopic treatment for male

Table 1 Distribution of the standard technique as applied in German hospitals

	OA (%)	LA (%)	SPA (%)	NA (%)	Other (%)
Male patients	13.3	85.2	0.7	0	0.8
Female patients	7.4	89.1	0.7	0	2.8

OA open appendectomy; *LA* laparoscopic appendectomy; *SPA* single port appendectomy; *NA* NOTES appendectomy

Table 2 Gender-specific distribution for open (OA) and laparoscopic (LA) appendectomy as applied in German hospitals (McNemar's test, *p*<0.001)

	OA male patients (%)	LA male patients (%)
OA female patients	7.5	0
LA female patients	5.6	86.9

patients and open treatment for female patients. The distribution was significant (*p*<0.001).

Details of the open approach

Perioperative antibiotic prophylaxis and antibiotic treatment depending on the intraoperative finding are widely used in OA (Table 3). Figure 3 shows the distribution of the different types of antibiotics. Duration of antibiotic treatment had a mean of 3.4 days (see also Fig. 4). McBurney incision is the preferred access (71.8 %) over a pararectal incision (24.1 %). A median infraumbilical laparotomy is also performed for findings with significant peritonitis. The preferred technique for dividing of the appendix is a tie at its base and then dividing it using a scalpel, the mesoappendix is mostly ligated (Table 3). The appendix stump is inverted using a purse string suture and a Z-suture in 75.5 %, purse string suture only in 16.8 %, Z-suture only in 2.7 %, and neither in 4.9 %. During OA, 48.1 % routinely flush the site, with usually <1,000 ml (89.1 %, see Fig. 5). With a lower number of appendectomies and more OA, flushing becomes more unusual for OA (<100, 42.6 %; 100–149, 54.8 %; ≥150, 51.5 %; *p*=0.042 and OA/OA, 29.3 %; LA/OA, 48.4 %; LA/LA, 50.3 %; *p*=0.015). Usage of an abdominal drain is seen in Table 3, the type of drain used in Fig. 6, duration in Fig. 7. There is a negative correlation for placement of a drain with the amount of appendectomies performed (*p*=0.031). A subcutaneous Redon drain is placed infrequently (Table 3). Table 3 shows the technique of wound closure. There was a positive correlation between both the amount of appendectomies performed and the care level of the hospital with the use of intracutaneous, resorbable sutures for skin closure (<100, 31.3 %; 100–149, 35.5 %; ≥150:,47.8 %; *p*=0.039; and low-level, 29.8 %; mid-level, 43.3 %; referral center, 46.0 %; university hospitals, 75.0 %; *p*<0.001). Average postoperative hospital stay following OA is 3.6 days (Fig. 8). Duration of hospital stay negatively correlates with the number of procedures performed (*p*=0.011).

An appendectomy "en principe" in open surgery is performed in 64.7 % in case of the intraoperative finding of an inconspicuous appendix, but an intraabdominal pathological findings that explain the symptoms

(e.g., Meckel's diverticulitis or gynecological finding) (Table 4). Hospitals that have LA as a standard for both male and female patients leave the appendix in situ significantly more frequently in these cases compared to hospitals that only operate open on male patients and those that operate open, regardless of the gender (LA/LA, 27.2 %; LA/OA, 16.1 %; OA/OA, 9.3 %; *p*=0.001). Figures for action in case of an inconspicuous appendix are shown in Table 4. The appendectomy "en principe" positively correlates with the amount of operations per year (<100, 89.9 %; 100–149, 90.4 %; ≥150, 94.2 %; *p*=0.043).

Table 3 (Peri)operative details for open (OA) and laparoscopic (LA) appendectomy

Variable	OA (%)	LA (%)
Antibiotics		
General therapy	1.4	0.9
Antibiotic prophylaxis	55.1	56.2
Depending on intraoperative finding	43.4	42.6
Never	0.2	0.3
Appendix		
Ligation	93.8	n.a.
Stapling device/endo-GIA	3.6	66.6
Endoloop only	n.a.	24.2
Endoloop with purse string/Z-suture	n.a.	2.6
Resorbable clips	0.9	15.1
Nonresorbable clips	0.3	9.2
Monopolar coagulation	n.a.	6.4
Lavage routinely		
Yes	48.1	49.9
No	51.9	50.1
Abdominal drain		
Always/mostly	9.5	8.3
Rarely/never	21.4	34.5
Depending on intraoperative finding	69.1	57.2
Subcutaneous Redon drain		
Always/mostly	4.5	n.a.
Rarely/never	75.6	n.a.
Depending on intraoperative finding	19.9	n.a.
Subcutaneous suture		
Always/mostly	42.6	n.a.
Rarely/never	42.4	n.a.
Depending on intraoperative finding	15.0	n.a.
Skin closing		
Intracutatneous and resorbable	36.5	48.3
Interrupted sutures	35.2	44.8
Staples	14.1	3.1
Intracutaneous and non resorbable	10.3	3.8

n.a. not applicable

Fig. 3 Distribution of antibiotics used for open (OA) and laparoscopic (LA) appendectomy
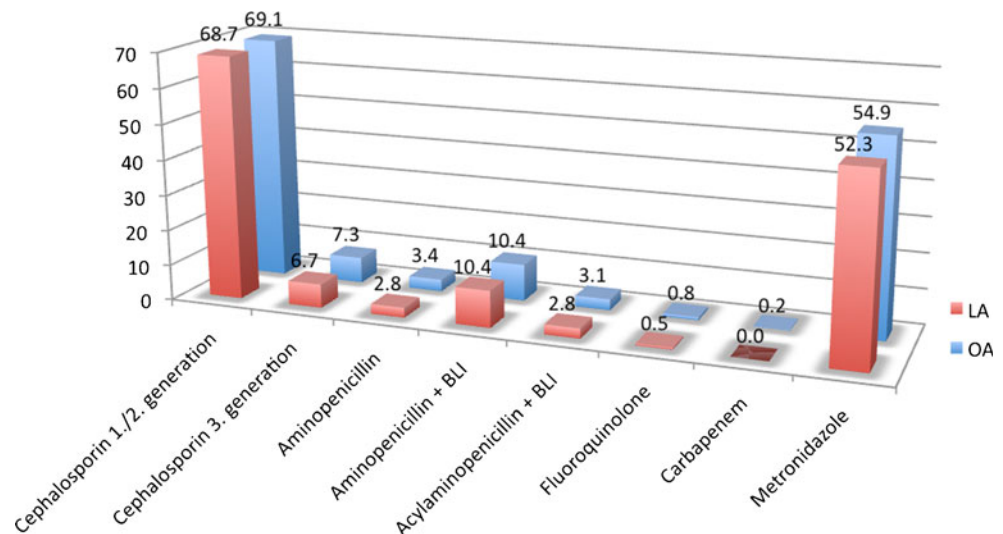
Details of the laparoscopic approach

The usage of antibiotics in the laparoscopic approach is listed in Table 3 and the types of antibiotics in Fig. 3. Mean duration of antibiotic therapy is 3.2 days, the exact distribution can be seen in Fig. 4. The access for establishing the capnoperitoneum is seen in Table 5. Interestingly, application of the Veress needle correlates negatively with the number of appendectomies per year (<100, 55.1 %; 100–149, 48.1 %; ≥150, 36.0 %; $p<0.001$), the care level of the hospital (low level, 54.0 %; mid-level, 42.7 %; referral center, 44.0 %; university hospital, 14.8 %; $p<0.001$), and the size of the department (<40, 53.8 %; 41–60, 51.0 %; 61–80, 42.7 %; 81–100, 36.1 %; >100, 25.0 %; $p=0.002$). Table 5 also shows details of trocars used. Dividing of the appendix in laparoscopic technique is mostly done by means of an Endo-GIA (Table 3). Usage of an Endo-GIA positively correlates with the number of procedures performed (<100, 59.9 %; 100–149, 74.7 %; ≥150, 71.1 %; $p=0.007$). Additionally, it

depends on the hospital operator, most significantly for hospitals with a private operator (state, 56.9 %; communal, 67.7 %; nonprofit, 62.3 %; private, 78.2 %; $p=0.021$). During LA, the mesoappendix is mostly controlled with bipolar co-agulation (Table 3). Half the hospitals routinely flush the site during LA, like in OA using <1,000 ml, (93.8 %, Fig. 5). Table 3 shows the usage of intraabdominal drains, and Fig. 6 shows the data for different types of drains. Mean duration of drainage is 2.1 days (Fig. 7). Skin closing technique is listed in Table 3. The use of intracutaneous, resorbable sutures in LA positively correlates with the number of procedures and the care level (<100, 42.0 %; 100–149, 46.6 %; ≥150, 63.2 %; $p=0.001$ and low-level, 40.5 %; mid-level, 56.5 %; referral center, 62.0 %; university hospital, 92.6 %; $p<0.001$). In addition, the type of standard procedure positively correlates with that type of skin closure (LA/LA, 49.8 %; LA/OA, 41.9 %; OA/OA, 29.3 %; $p=0.015$). The mean postoperative hospital stay after LA is 2.9 days (Fig. 8). The postoperative hospital stay significantly depends on the number of

Fig. 4 Duration of antibiotic treatment in open (OA) and laparoscopic (LA) appendectomy
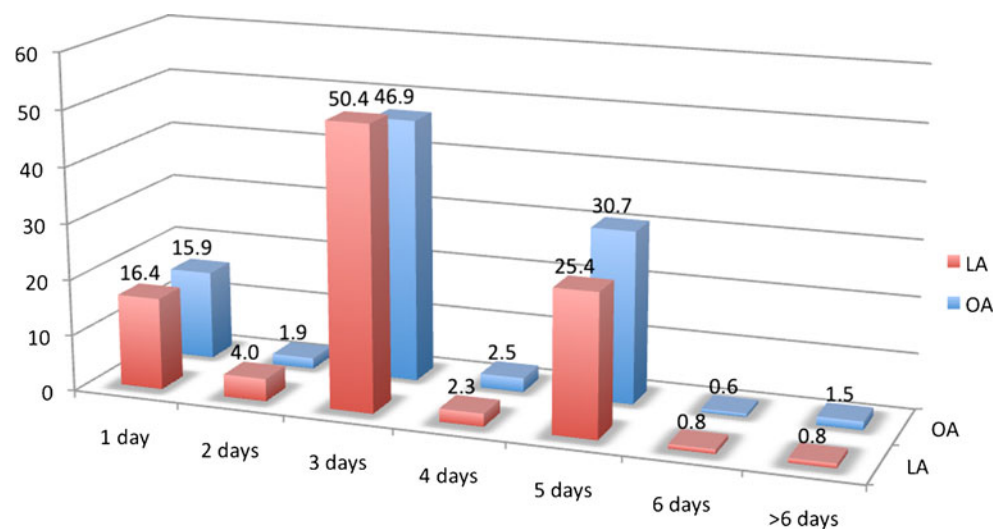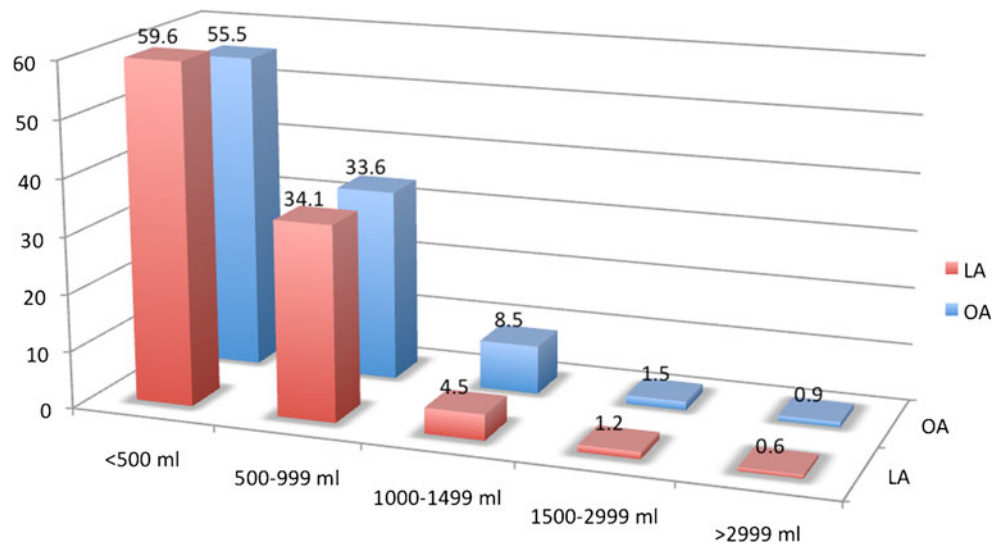
Fig. 5 Amount of intraoperative flushing in open (OA) and laparoscopic (LA) appendectomy

procedures performed and the standard procedure: the more appendectomies, the shorter the postoperative hospital stay ($p<0.001$), and a longer postoperative hospital stay for the standard of OA ($p=0.001$).

Actions in case of the intraoperative finding of an inconspicuous appendix during laparoscopy are shown in Table 4. Leaving the appendix correlates negatively with the number of operations per year (<100, 10.6 %; 100–149, 2.5 %; ≥150, 3.0 %; $p=0.001$).

Discussion

Appendectomy is the gold standard therapy for acute appendicitis [1]. In 2010, it was performed 123,134 times in Germany, making it the third most frequent emergency operation. It ranks 31 among the most frequent inpatient operations [2]. Distribution of gender is almost equal (male patients, 46 %; female patients, 54 %). For a period of more than 20 years,

documentation of this surgical procedure was mandatory for all German hospitals. Data were collected by the BQS, the federal institute for quality and patient safety. The aims of this quality control were to establish a frequent confirmation of the preoperative working diagnosis "acute appendicitis" by means of histopathological workup of all appendectomies, a short preoperative hospital stay in case of a histologically found perforation, rare postoperative wound infections, as well as rare general postoperative complications requiring treatment. Thus, no intraoperative details were itemized apart from procedural code and procedural time. Only procedures were analyzed in which an appendectomy was performed, making it impossible to raise data about the management of an inconspicuous appendix during a procedure planned as an appendectomy. This compulsory nationwide survey was gradually abandoned state by state from 2004 until 2008. No comprehensive survey reflecting the clinical reality and quality of this frequent procedure has been performed since. The explanation given for abandoning the survey was a stable,

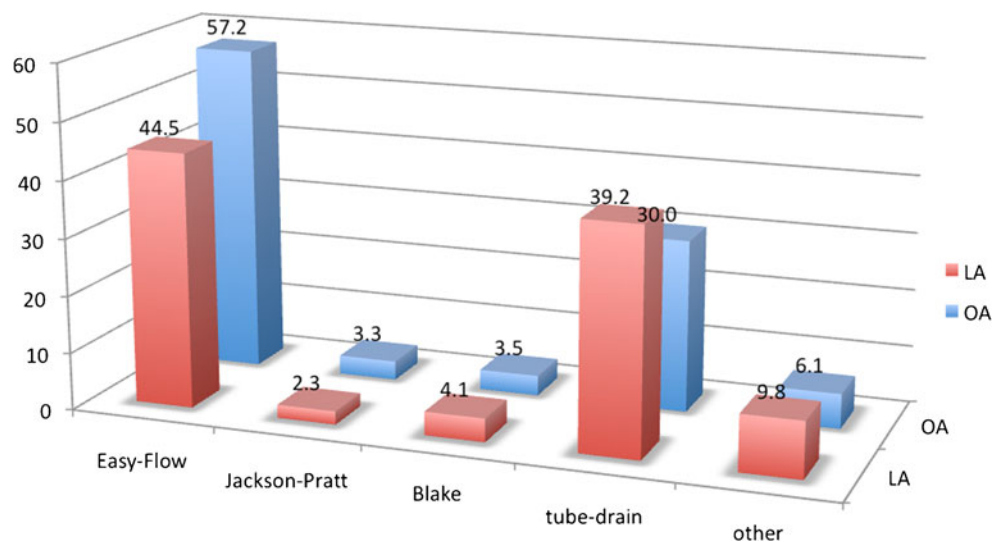**Fig. 6** Types of drains used in open (OA) and laparoscopic (LA) appendectomy
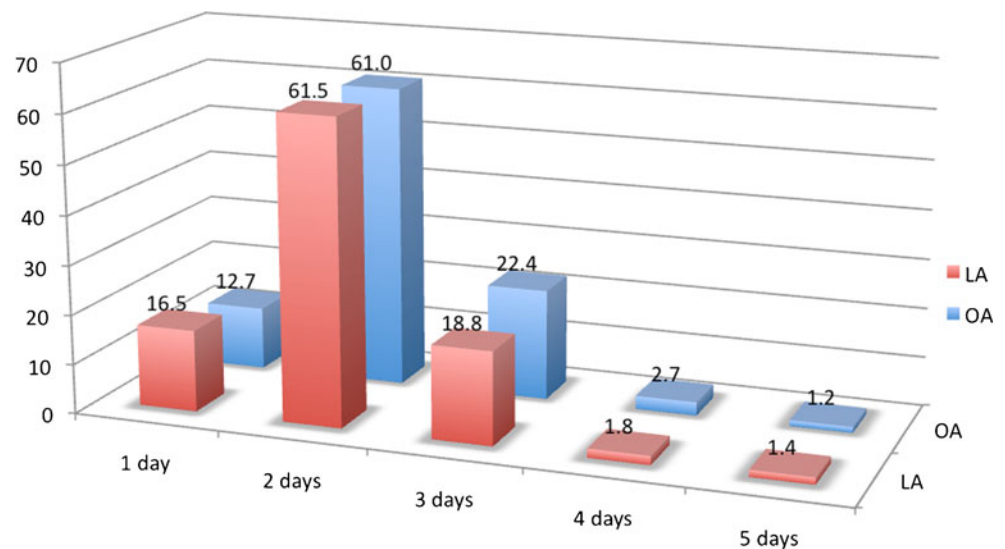
Fig. 7 Duration of abdominal drainage in open (OA) and laparoscopic (LA) appendectomy

high therapeutic quality, and a lack of new developments in this area.

After Semm performed the first LA in 1980 [3], this new technique was picked up only slowly. In 2003, the last year of the survey in all states, 43.9 % of all appendectomies were conducted laparoscopically, with a conversion rate of 6.3 % [4]. In the Bavarian survey, for the first time in 2006, appendectomies were more frequently performed laparoscopically than open; in 2008, the figure reached 63.9 % (data from the "Bayerischen Arbeitsgemeinschaft für Qualitätssicherung": www.baq-bayern.de).

Meanwhile, there are a number of prospective randomized trials, meta-analyses, and Cochrane analyses comparing LA, OA, and different details concerning the operative procedure itself. It remains unclear, however, if and how far the resulting recommendations are being adapted in clinical practice.

In a Cochrane analysis by Sauerland et al. [5], the rate of wound infections, pain on the first postoperative day, duration

of hospital stay, postoperative return to solid food, first postoperative bowel movement, surgery-related aesthetics, and return to normal activity were significantly better after LA as compared to OA. On the other hand, for LA, the rates of intraabdominal abscesses, procedural time, and the costs of LA and its overall hospital-related costs were significantly higher. However, the costs after discharge from the hospital were significantly lower for LA. The costs related to the surgical procedure itself greatly depend on the surgeon's choice for type of trocar and the technique for control of the mesoappendix and the appendix stump. In a study by Chu et al. [6], these three factors alone affect costs to vary between $81 and $873. Our data show that the majority in Germany uses resterilizable trocars, most likely for financial reasons. Despite the partly marginal advantages and a limited clinical relevance, Sauerland et al. recommended the laparoscopic technique. Especially young, female, obese, and working patients seem to profit from this technique. A further Cochrane review confirmed the recommendation of LA for

Fig. 8 Postoperative hospital stay after open (OA) and laparoscopic (LA) appendectomy
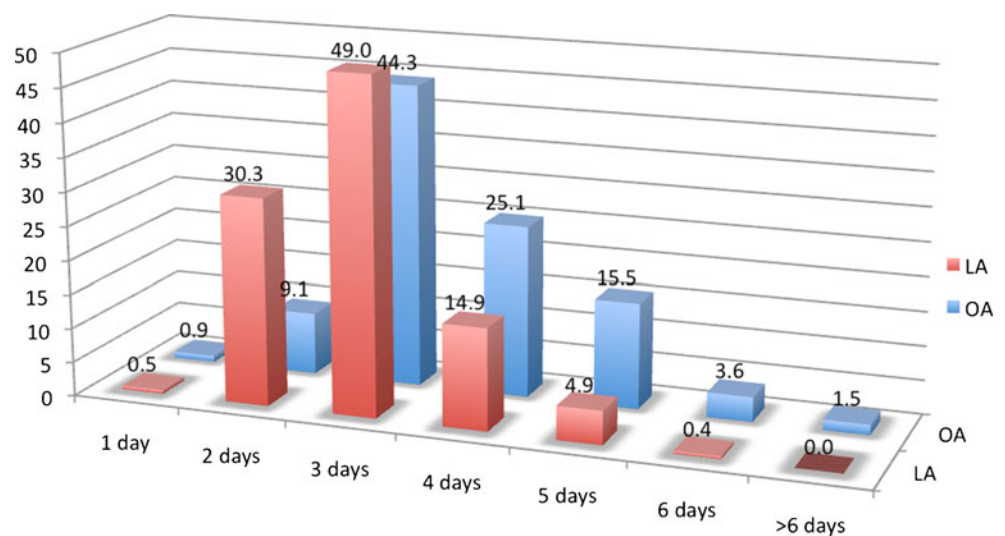
Table 4 Action in case of the intraoperative finding of a macroscopically inconspicuous appendix

Inconspicuous appendix	OA (%)	LA (%)
Intraabdominal pathological finding other than appendicitis		
Appendectomy "en principe"	64.7	54.8
No appendectomy	24.9	34.5
Other	10.4	10.7
Absence of intraabdominal pathological findings		
Appendectomy "en principe"	91.2	88.4
No appendectomy	3.4	6.4
Other	5.4	5.2

women of child-bearing age due to a lower rate of resection of inconspicuous appendices and a higher diagnostic value as compared to OA, however, without reducing the rate of adverse events [7]. The significantly lower rate of negative appendectomies following the routine use of laparoscopy was confirmed in another trial [8]. In our data, too, this was a reason for some hospitals to define LA as the standard procedure in female patients. Laparoscopy frequently reveals differential-diagnostic findings, which can mostly even be treated laparoscopically [9], but would remain unseen in OA. There is evidence for LA as an abdominal emergency procedure in pregnant women not affecting survival rates in mothers and unborn children [10]. A recently published meta analysis of 25 studies including 2,220 LAs and 2,474 OAs showed less postoperative complications and pain, an earlier

Table 5 Operative details for laparoscopic appendectomy (LA)

Variable	LA (%)
Establishing the capnoperitoneum	
Veress needle	48.7
Open access	48.7
Trokars	
Reusable	76.8
Single use trokars	18.2
Combination of both	5.0
Numbers of trokars	
3	97.0
2	2.1
1	0.9
Diameter of trokars	
2 mm	1.2
2.5 mm	0.5
2.8 mm	0.8
3 mm	3.3
5 mm	86.6
10 mm	75.0
13 mm	40.0

return to food intake, a shorter hospital stay, and an earlier return to work and normal activity in the LA group [11], all significant. Hospital-related costs in that analysis did not differ significantly, but the procedural time in the LA group was significantly longer. A subgroup analysis in a randomized, prospective, double- blinded trial with 37 overweight patients (BMI ≥30 kg/m^2) did not show an advantage of LA compared to OA, but a significantly longer procedural time in the LA group [12].

The European Association for Endoscopic Surgery recommends LA in their evidence-based guidelines for the treatment of suspected acute appendicitis due to a significantly lower rate of wound infections and quicker postoperative recovery [13]. The Society of American Gastrointestinal and Endoscopic Surgeons, too, recommends LA in different patient collectives [14].

A large health care study including 4,068 patients from 29 German hospitals in the years 2008/2009 confirmed a significantly lower rate of wound infections and shorter hospital stay, but not a higher rate of intraabdominal abscesses [15]. The significantly shorter procedural time and the lower abscess rate for LA might be explained with the different patient collectives, which also showed a different distribution for patients' ASA classification between both techniques.

In an analysis of the American College of Surgeons National Surgical Quality Improvement Program Database with 222 enrolled hospitals including 32,683 patients, LA was the treatment of choice in 76.4 % [16]. Here, too, the openly operated patients were older on average and had more comorbidities. LA resulted in a significantly lower overall morbidity and less wound infections. After complicated appendicitis was treated with LA, however, there were significantly more intraabdominal abscesses. In a 12-year-analysis of the Swiss Association of Laparoscopic and Thoracoscopic Surgery, Brugger et al. [17] found significant improvement over time in terms of conversion rate, intra-operative and postoperative complications, reoperations, and hospital stay. Similar findings were reported by Sporn et al. Higher costs for LA were decreasing over time [18]. A workup of 259,735 appendectomies conducted in the UK found a significantly lower 1-month and 1-year lethality with a shorter hospital stay, but higher readmission rate after LA as compared to OA [19]. An analysis of the US-American University Health System Consortium database including 40,337 patients showed a significantly better outcome of LA for both uncomplicated and complicated as well as perforated appendicitis [20]. Similar benefits of LA as compared to OA were found in a retrospective analysis by Katsuno et al. [21]. The acceptance of LA as the standard procedure was confirmed by our data, whereas the even higher rate for female patients reflects the advantages of the laparoscopic approach especially for this collective.

Two novel ways of the abdominal access route, the single-port technique and NOTES (natural orifice transluminal surgery), have emerged in recent years. Their distribution was unknown. The German Society for General and Visceral Surgery (DGAV) started the national NOTES registry for NOTES procedures in February 2008. Appendectomies, among other procedures, can be registered [22]. The single-port technique is supposed to avoid visible scars by introducing all instruments through a single port at the umbilicus. The French surgeon Georges Begin performed the so called "transumbilical laparoscopically assisted appendectomy" (TULAA) with a sole umbilical access as early as 1989 [23]. This technique has been evaluated in several case series [24, 25]. However, neither is there a randomized controlled trial for this technique nor for its recent offspring with a multichannel port (SPA) [26]. A nonrandomized trial did not find a difference between SPA and LA in the early postoperative course apart from a shorter incision length [27]. The obvious advantage of better aesthetics is countered by impaired triangulation, though. The same difficulties occur with the NA, which was first performed for suspected appendicitis in transvaginal hybrid technique in 2007 [28] and as a pure transvaginal NOTES procedure by Bernhardt et al. [29] in the same year. Gynecologists already performed transvaginal appendectomies during transvaginal hysterectomies more than 60 years ago and during laparoscopically assisted vaginal hysterectomies in the 1990s [30]. Transvaginal retrieval of the appendix was published by gynecologists already in 1993 [31]. Hybrid-NOTES appendectomies have even been performed through a transgastral route [32]. However, our German data show that SPA is performed rarely and NA even less. Reduced postoperative pain or need for analgesics after the use of laparoscopic mini-instruments (2–3.5 mm) was shown for a number of surgical procedures, but not verified for appendectomy [33, 34]. According to our data, needlescopic appendectomy is not widely used in Germany.

With regard to perioperative antibiotic prophylaxis and therapy, a Cochrane review shows that systemic administration of antibiotics significantly lowers the rate of wound infections and intraabdominal abscesses as well as the duration of hospital stay [35]. For children, this effect was not verified in a double-blinded, randomized controlled trial, where in OA for nonperforated appendicitis in children, no antibiotic treatment was compared to a 5-day antibiotic prophylaxis [36]. Our survey showed that administration of antibiotics, either as a prophylaxis or therapy, is a standard in almost all German hospitals, regardless of the applied surgical technique. However, many other details of the appendectomy remain controversial. About half the German hospitals prefer the Veress needle, although a recently published Cochrane analysis shows a significantly higher rate of failed entries, extraperitoneal CO_2 insufflation, and injuries

of the greater omentum for this technique [37]. A meta-analysis compared staplers versus the endoloop technique for LA [38]. A significant advantage for stapler appendectomy was found for wound infections and postoperative ileus. The significantly lowered rate of intraabdominal abscesses and readmissions that were found in a non randomized trial [39] were not confirmed by the meta-analysis. A large case series published on the subject can only be evaluated restrictively, as it was biased by the use of stapler devices for extensive inflammation, i.e., in cases with a higher risk of infection [40]. A nonrandomized controlled study showed advantages of a nonresorbable polymer clip against the endoloop in terms of simple application, procedural time, and costs [41]. For the usage of titanium clips, there are only case series [42, 43]. According to our data, in Germany, the stapler appendectomy is the preferred technique for LA. There is no valid data for the dividing of the appendix in OA. We found that Germans mostly tie it off at its base and use a purse string suture and/or Z-suture. For control of the mesoappendix, there are no randomized controlled trials, either, which is why we received widely varying responses for LA. On the other hand, the mesoappendix is usually controlled by ligation during an OA, certainly due to lower costs and availability. Intraoperative flushing, especially during LA, is controversial, as it may reduce bacterial contamination or result in an unintended microbial distribution into the abdomen [44]. Answers in the questionnaire vary accordingly for both LA and OA.

A meta-analysis found a tendency against the placement of a drain due to wound infections, intraabdominal abscesses, and a significantly higher rate of stool fistulas after placement of a drain [45]. In our data, a drain is mostly placed in both OA and LA, depending on the intraoperative finding (Table 3). Skin closure technique was evaluated in a prospective randomized trial including 166 children undergoing OA. No evidence was found against a continuous resorbable suture as compared to nonresorbable interrupted stiches [46]. Currently, continuous intracutaneous resorbable sutures are the preferred technique for both OA and LA in Germany.

A very important point is the management of the intraoperative finding of an inconspicuous appendix during an operation for suspected acute appendicitis. In the absence of an intraabdominal pathological finding explaining the symptoms, the appendectomy "en principe" is recommended due to the high rate of histologically found appendicitis despite a macroscopically inconspicuous appearance in 26–58 % of cases [47–49]. Still, leaving the inconspicuous appendix in situ rarely leads to a reoperation for acute appendicitis [50]. The high German rate (about 90 %) of "en principe" appendectomies in these cases, both during OA and LA, is therefore certainly justified. On the other hand, a simultaneous removal of the inconspicuous appendix is not mandatory in case of a

pathological finding other than appendicitis, which explains the symptoms and can be treated intraoperatively. This is reflected by our data with a much lower rate of "en principe" appendectomies in these cases. The higher rate for OA is explained by the impaired abdominal overview, which can obscure other pathological findings and the traditional view of a scar in the right lower quadrant as an indicator for a previous appendectomy.

Conclusions

We conducted this nationwide survey to document the current standard of care for appendectomies in Germany and to compare it with existing data. The minimally invasive technique offers only limited advantages for male patients and patients with normal weight. However, regardless of a patient's gender, LA is the standard of care in most German hospitals. This shows the increasing distribution of LA, which was already documented in the federal survey. The Veress needle is still widely used, although disadvantages are known. Stapler appendectomy in LA has mostly established itself despite higher costs, while the appendix is divided according to long-established standards during OA. Intraoperative flushing is performed quite variably, regardless of the surgical technique. A macroscopically inconspicuous appendix is regularly removed in the absence of other pathologies, and often in case of other pathological findings, in both cases regardless of the surgical technique.

The survey describes the current status of appendectomy in Germany. There may, however, be a selection bias of the responders. The given responses are not necessarily the actual practice within the department, but rather represent the internal standard as favored by the head of department.

The partly heterogeneous data shown may indicate a need for the establishment of guidelines for appendectomy.

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