Surgeon and patient-specific factors influencing the decision for minimally invasive or open surgery in acute bowel obstruction: a retrospective single-center analysis

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Abstract

Purpose Despite continuous improvement in minimally invasive surgery (MIS) and growing evidence for its superiority in procedures in various organ systems, a routinely application in patients with acute bowel obstruction (ABO) cannot be seen to date. Besides very general explanations for this attitude, not much is known about the decision process in a particular patient. This retrospective study aims at investigating surgeon- and patient-specific factors for or against MIS in acute bowel obstruction.

Methods A retrospective analysis of all patients undergoing either MIS or open surgery (OS) for ABO at a single center between 2009 and 2017 was performed. All available preoperative parameters were included in the analysis and subdivided into patient- (age, gender, BMI, previous abdominal procedures, inflammatory process, ASA score, bowel dilatation) and surgeon-specific (time of patient admission, senior surgeon performed the procedure or taught the case, availability of a surgical resident or junior doctor as assisting surgeon) factors. Statistical analysis was performed to reveal their influence on the surgeon’s decision for or against MIS.

Results Of 106 patients requiring surgical intervention, 57 were treated by OS (53.77%) and 49 by MIS (46.23%). Patients with a higher ASA score (ASA III) and a bowel width of ≥ 3.8 cm in preoperative radiologic imaging were more likely to undergo OS (p < 0.01). Also, a late admission time to the hospital (x̄ = 14.78 h) was associated with OS (p = 0.01). Concerning previous abdominal surgical interventions, patients with prior appendectomy rather were assigned to MIS (p < 0.01) whereas those with prior colectomy to OS (p < 0.01).

Conclusions The choice of procedure in patients with bowel obstruction is a highly individualized decision. Whereas scientifically proven parameters, such as high age and BMI, had no influence on the decision process, impaired general health condition (ASA score), high bowel width, previous surgical intervention, and a late admission time influenced the decision process towards open surgery.

Trial registration Retrospectively registered with the German Clinical Trials Register: DRKS00021600.

Keywords Acute bowel obstruction · Minimally invasive surgery · Open surgery · Laparoscopy

Background

Acute bowel obstruction (ABO) is one of the most common surgical diagnoses in emergency care units worldwide [1]. The most common reasons for bowel obstruction are adhesions from previous operations [1, 2]. Twenty to thirty percent of patients with ABO require surgical treatment [3].

Minimally invasive surgery (MIS) is established and safe for a variety of surgical procedures. Compared to conventional open surgery (OS), MIS provides advantages in terms of morbidity, length of stay (LOS), and postoperative recovery [4–9].
Despite some convincing data [5] and increasing recommendations from surgical societies [3] arguing for more frequent application of MIS for ABO, wider implementation for this indication has not been witnessed to date [3, 10].

Prevalent arguments against MIS include lack of sufficient education and training, higher costs than for OS, and reduced exposure of the dissection area, which may increase the risk for bowel perforation [11, 12]. However, these arguments promote any effort for a better training in MIS and a reduction of costs.

It is remarkable that little is known with regard to patient- and surgeon-specific parameters influencing the surgeon’s preference for MIS or OS.

The aim of the study was to focus on confounding factors that could influence the surgical decision for or against a minimally invasive approach in patients with ABO regardless of the postoperative outcome of the patient cohorts.

**Methods**

The study was conducted in a community-based hospital where both elective and emergency abdominal surgeries are performed. The surgical department performs a total of 2500 procedures a year with a focus on MIS, including at least 250 advanced MIS, such as colorectal and upper gastrointestinal (GI) procedures.

All procedures were done by or under the supervision of six senior surgeons being trained in advanced MIS and OS. Every senior surgeon has already performed at least 100 advanced MIS (colorectal and upper GI) as well as more than 100 complex OS procedures. Assisting surgeons were subdivided into senior surgeons, surgical residents (training years 1–6), and junior doctors with no surgical experience. We retrospectively analyzed the surgical teams on duty.

The policy of the department is the liberty of each surgeon to decide on the type of surgical approach to be taken without limitations imposed by superiors or financial restrictions.

After admission of the patient to the emergency department all patients were seen by an emergency medicine specialist. Laboratory and radiological testing were performed. All patients with a clinical and/or radiological diagnosis of bowel obstruction were seen by a senior surgeon to indicate surgery or conservative treatment, based on the available clinical and radiological testing. If surgery was necessary, the procedure was determined and the patient was seen by an anesthesiologist. Open and MIS procedures followed standardized surgical protocols and the postoperative course was electronically documented. The patient data were recorded electronically; the chart includes all relevant patient- and procedure-specific parameters. We assessed the following: age, gender, body height, weight, blood pressure, body temperature, patient’s medical history, medication, American Association of Anesthesiologists (ASA) score, lab findings, radiological findings, pre- and post-operatively documented ward rounds, nursing documentation, and procedural data (time of surgery, duration, involved team, consumables).

Data on all surgical procedures for ABO between January 1, 2009 and December 31, 2017 were acquired with the following algorithm: a search was conducted for all patients with ABO as an ICD 10 (International Statistical Classification of Diseases and Related Health Problems) diagnosis and a surgical procedure for bowel obstruction during the same stay. The resulting dataset was matched with an electronic file of all procedures performed in this time period and an Excel database (Microsoft Excel, Microsoft Corporation, Redmond, Washington (WA), USA) was created. Two patients with an anesthesiologic contraindication for MIS were excluded from this study.

All patients were assigned to two different surgical groups: Group 1 with primary OS and Group 2 with primary MIS.

Group 2 comprised patients who underwent multiport laparoscopy (MPL; i.e., three or more trocars at different abdominal locations) and single-incision laparoscopy (SIL; single port for camera and instruments at the umbilicus). A subgroup analysis was performed in the second group comparing results for these two MIS techniques.

All parameters were categorized in patient- and surgeon-specific factors:

- **Patient-specific factors**: age, gender, BMI, number and type of previous abdominal procedures (previous abdominal procedures were assigned to one of the following groups: multiple abdominal interventions, OS of any kind, MIS surgery of any kind, appendectomy (AE), colonic surgery, upper GI and urological/gynecological), inflammatory process (CRP > 0.5 mg/dl), ASA score, and grade of bowel dilatation (maximum diameter in centimeters).

- **Surgeon-specific factors**: time of patient admission (admission time was assigned to surgeon specific factors, as it directly influences the beginning time of surgery and not the clinical condition of the patient), senior surgeon performed the procedure or taught the case, availability of a senior surgeon, a surgical resident, or junior doctor as assisting surgeon.

**Statistical analysis**

A mathematician not involved in patient assessment (T. H.) conducted the statistical analyses using R, version 4.0.5. All statistical assessments were two-sided and a significance level of 5% was applied. Group differences were assessed with the Wilcoxon rank sum test for continuous variables and Fisher’s exact test for binary variables. Continuous data are presented as median (25th to 75th percentile) and...
categorical variables as frequencies (%). Effect size and precision are shown with estimated median differences between groups for continuous data and odds ratios (OR) for binary variables, with 95% confidence intervals (CIs).

**Results**

A total of 106 consecutive patients with ABO required surgical intervention. Of these, 57 were treated with OS (Group OS; 53.77%) and 49 with MIS (Group MIS; 46.23%). The number of conservatively treated patients during the study period was 134.

All results regarding patients’ preoperative condition are given in Table 1. Neither age, BMI, nor gender or inflammatory parameters were found to be independent parameters for the decision-making process towards MIS or OS. There was a significant association between a high ASA score (ASA III) and OS ($p < 0.01$). Patients treated with MIS had a significantly lower bowel width, than patients treated by OS ($3.5 \text{ vs. } 3.8 \text{ cm}$, $p < 0.01$). Regarding previous abdominal surgery, patients with prior colectomies were more likely to be treated in open surgery ($p < 0.01$), while patients with a prior appendectomy were more likely to be treated with MIS ($p < 0.01$). A tumor as a reason for ABO showed a significant correlation for OS ($p < 0.01$).

All results regarding surgeon-specific conditions are given in Table 2. Neither the fact that the senior surgeon conducted the procedure himself or taught the case nor the availability of an experienced assisting surgeon showed any significant difference concerning the type of surgical approach. In contrast, a late admission time after 14:45 h showed a significant correlation with OS ($p \leq 0.01$).

### Table 1 Patient-specific parameters influencing decision making in ABO

| Parameter                        | Total ($n = 106$) | MIS ($n = 49$) | Open ($n = 57$) | Estimate$^b$ with 95% CI | $p$ Value$^c$ |
|----------------------------------|-------------------|---------------|-----------------|--------------------------|--------------|
| Age (year)                       | 70 (60.25–79)     | 68 (57–79)    | 71 (62–79)      | $-2 (-8 \text{ to } 3)$  | 0.4208       |
| Female gender                    | 68/106 (64.2%)    | 27/49 (55.1%) | 41/57 (71.9%)   | 2.07 (0.86 to 5.07)      | 0.1037       |
| BMI (kg/m$^2$)                   | 23.1 (20.5–26.53) | 23.8 (21.4–26.1) | 22.5 (20.2–27) | 0.4 (1.2 to 2)           | 0.5857       |
| Inflammation (CRP > 0.5 mg/dl)   | 57/106 (53.8%)    | 23/49 (46.9%) | 34/57 (59.6%)   | 1.66 (0.72 to 3.88)      | 0.2418       |
| ASA I                            | 17/106 (16%)      | 12/49 (24.5%) | 5/57 (8.8%)     | 0.3 (0.08 to 1.01)       | 0.035        |
| ASA II                           | 42/106 (39.6%)    | 25/49 (51%)   | 17/57 (29.8%)   | 0.41 (0.17 to 0.97)      | 0.0301       |
| ASA III                          | 46/106 (43.4%)    | 11/49 (22.4%) | 35/57 (61.4%)   | 5.4 (2.17 to 14.33)      | 0.0001       |
| Bowel width (cm)                 | 3.5 (3–4.1)       | 3.5 (3–3.6)   | 3.8 (3.5–5)     | $-0.5 (-1 \text{ to } -0.2)$ | 0.0006       |

### Table 2 Surgeon-specific parameters influencing decision making in ABO

| Parameter                        | Total ($n = 106$) | Laparoscopic ($n = 49$) | Open ($n = 57$) | Estimate$^b$ with 95% CI | $p$ Value$^c$ |
|----------------------------------|-------------------|-------------------------|-----------------|--------------------------|--------------|
| Senior surgeon responsible       | 82/106 (77.4%)    | 37/49 (75.5%)           | 45/57 (78.9%)   | 1.21 (0.44 to 3.35)      | 0.8165       |
| Experienced assisting surgeon    | 68/106 (64.2%)    | 33/49 (67.3%)           | 35/57 (61.4%)   | 0.77 (0.32 to 1.85)      | 0.5491       |
| Admission time (h)               | 12.47 (8.97–16.94)| 10.88 (8.12–14.67)      | 14.78 (9.72–17.98) | $-2.9 (-5.27 \text{ to } -0.63)$ | 0.0111       |
The subgroup analysis of MPL and SIL within the MIS group revealed no significant difference in any parameter between these two subgroups. These results are given in Table 3.

A distribution analysis among the years of admission and the type of surgical approach did not reveal any significant difference ($p = 0.2113$).

Intraoperative conversion from MIS to OS was performed in 10 cases (20.4%). Thereof, 8 conversions were made due to strategic reasons and 2 due to iatrogenic bowel injury.

Postoperative complication rates are shown in Table 4. Mortality was 2% and 5.3% in the MIS and OS cohort, respectively.

**Discussion**

Factors that influence decision making on surgical strategy in patients with ABO are manifold. In contrast to the general understanding that surgical strategy for or against

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### Table 3

| Factor                                | Total (n=49) | Multiport (n=21) | SIL (n=28) | Estimate\(^a\) with 95% CI | p Value\(^b\) |
|---------------------------------------|--------------|-----------------|------------|---------------------------|--------------|
| Age (year)                            | 68 (57–79)   | 62 (52–78)      | 70.5 (64–80.25) | −5 (−16 to 6) | 0.3221 |
| Female gender                         | 27/49 (55.1%)| 11/21 (52.4%)   | 16/28 (57.1%) | 1.21 (0.33 to 4.37) | 0.7786 |
| BMI (kg/m\(^2\))                      | 23.8 (21.4–26.1) | 23 (20.5–24.5) | 23.85 (22.08–26.73) | −1.6 (−3.6 to 0.5) | 0.1633 |
| Inflammation (CRP > 0.5 mg/dl)        | 23/49 (46.9%)| 9/21 (42.9%)    | 14/28 (50%)   | 1.33 (0.37 to 4.85) | 0.7736 |
| ASA I                                 | 12/49 (24.5%)| 5/21 (23.8%)    | 7/28 (25%)   | 1.07 (0.24 to 5.11) | 1 |
| ASA II                                | 25/49 (51%)  | 11/21 (52.4%)   | 14/28 (50%)   | 0.91 (0.25 to 3.26) | 1 |
| ASA III                               | 11/49 (22.4%)| 5/21 (23.8%)    | 6/28 (21.4%)  | 0.88 (0.18 to 4.32) | 1 |
| Bowel width (cm)                      | 3.5 (3–3.6)  | 3.35 (2.98–3.65)| 3.5 (3–3.6)  | 0 (−0.5 to 0.4)  | 0.797 |
| Senior surgeon responsible            | 37/49 (75.5%)| 16/21 (76.2%)   | 21/28 (75%)  | 0.94 (0.2 to 4.2)  | 1 |
| Admission time (h)                    | 10.88 (8.12–14.67) | 12.3 (9.2–14.67) | 10.2 (8.07–14.34) | 1.1 (−2.33 to 4.22) | 0.5681 |
| Experienced assisting surgeon         | 33/49 (67.3%)| 13/21 (61.9%)   | 20/28 (71.4%)| 1.52 (0.39 to 6.05) | 0.5474 |
| Multiple abdominal                    | 12/49 (24.5%)| 6/21 (28.6%)    | 6/28 (21.4%)  | 0.69 (0.15 to 3.12) | 0.7389 |
| Open                                  | 26/49 (53.1%)| 14/21 (66.7%)   | 12/28 (42.9%)| 0.38 (0.1 to 1.4)  | 0.1488 |
| MIS                                   | 13/49 (26.5%)| 5/21 (23.8%)    | 8/28 (28.6%) | 1.27 (0.3 to 5.98) | 0.7553 |
| AE                                    | 13/49 (26.5%)| 6/21 (28.6%)    | 7/28 (25%)   | 0.84 (0.19 to 3.69) | 1 |
| Colon                                 | 7/49 (14.3%) | 3/21 (14.3%)    | 4/28 (14.3%) | 1 (0.15 to 7.7)   | 1 |
| Upper abdominal                       | 14/49 (28.6%)| 7/21 (33.3%)    | 7/28 (25%)   | 0.67 (0.16 to 2.8) | 0.5421 |
| Urological or gynecological           | 10/49 (20.4%)| 3/21 (14.3%)    | 7/28 (25%)   | 1.97 (0.38 to 13.57) | 0.4823 |
| Tumor as reason for bowel obstruction | 3/49 (6.1%)  | 0/21 (0%)       | 3/28 (10.7%) | Inf (0.31 to Inf)   | 0.25 |
| Senior surgeon responsible            | 37/49 (75.5%)| 16/21 (76.2%)   | 21/28 (75%)  | 0.94 (0.2 to 4.2)  | 1 |
| Admission time (h)                    | 10.88 (8.12–14.67) | 12.3 (9.2–14.67) | 10.2 (8.07–14.34) | 1.1 (−2.33 to 4.22) | 0.5681 |
| Experienced assisting surgeon         | 33/49 (67.3%)| 13/21 (61.9%)   | 20/28 (71.4%)| 1.52 (0.39 to 6.05) | 0.5474 |

\(^a\)Binary data are presented as no./total no. (%), continuous data as medians (25th to 75th percentile)

\(^b\)Odds ratios for binary variables and estimated median difference for continuous variables

\(^c\)Assessed by Fisher’s exact test for categorical variables and Wilcoxon rank sum test for continuous variables

### Table 4

| Grade (Dindo-Clavien) | Total (n=106) | Laparoscopic (n=49) | Open (n=57) | Estimate\(^a\) with 95% CI | p Value\(^b\) |
|-----------------------|--------------|-------------------|------------|---------------------------|--------------|
| 1                     | 65/106 (61.3%)| 36/49 (73.5%)     | 29/57 (50.9%)| 0.38 (0.15 to 0.91) | 0.0272 |
| 2                     | 18/106 (17%) | 5/49 (10.2%)      | 13/57 (22.8%)| 2.58 (0.78 to 10.04) | 0.1196 |
| 3b                    | 17/106 (16%) | 6/49 (12.2%)     | 11/57 (19.3%)| 1.71 (0.52 to 6.13) | 0.4283 |
| 4                     | 2/106 (1.9%) | 1/49 (2%)        | 1/57 (1.8%) | 0.86 (0.01 to 68.63) | 1 |
| 5                     | 4/106 (3.8%)| 1/49 (2%)        | 3/57 (5.3%) | 2.64 (0.2 to 142.75) | 0.6222 |

\(^a\)Odds ratios for binary variables and estimated median difference for continuous variables

\(^b\)Assessed by Fisher’s exact test for categorical variables and Wilcoxon rank sum test for continuous variables
MIS exclusively relies on traditional parameters, we were able to identify a decision-making process biased by non-traditional soft facts, such as admission time, patients’ history, and radiological findings. 

Old age can be regarded as one of the most established parameters when opting for an open approach in ABO. In a retrospective study with data from a prospectively maintained database, Valverde et al. investigated 262 patients with ABO undergoing surgery and showed that patients in the MIS group were significantly younger than in the OS group [13]. This finding was also detected by Grafen et al. in a review of 93 patients [14]. However, our own results did not show any significant association between age and type of surgical approach. This may be due to the fact that age as a single parameter does not allow any sound conclusion to be drawn concerning the patient’s health. Bearing in mind that a higher age is often associated with reduced physical health and a prolonged recovery period to regain the previous functional state, older patients should not be excluded from the advantages of a MIS procedure. As this group of patients may benefit remarkably from a MIS procedure, an application should be highly taken into consideration.

Another parameter that did not influence the surgeon’s decision in our study is the patient’s BMI. Although a high BMI is known to be associated with increased intraoperative difficulty and postoperative complications in abdominal surgery [15], in times of an obesity pandemic this fact should no longer discourage most surgeons from performing MIS. To underline this, a retrospective cohort study including 227 patients undergoing surgery for ABO between 2014 and 2016 showed an association between success of laparoscopy and BMI [16].

Concerning gender dependency on the decision process, the results of our study are in line with the preexisting literature [13, 14] and did not differ for males and females.

Nevertheless, closer examination reveals that poor health, namely, a higher ASA score (> ASA II), more often resulted in OS. This suggests that a diligent, individually adjusted patient evaluation is needed. Grafen et al. also revealed that patients undergoing MIS procedures showed lower ASA scores than did patients undergoing OS [14]. Even so, this indicates that a patient’s general health condition, in contrast to their age, still serves as guidance for the surgeon’s choice of strategy. According to the evidence that even frail patients with health burdens benefit from all endeavors to minimize the surgical incisional trauma, a rethinking process should be initiated to allow this patient group to benefit more often from the use of MIS techniques [17, 18].

Predictably, the number and type of previous abdominal interventions had an influence on the decision for or against MIS. Patients with a prior appendectomy were more likely to be treated by MIS. This finding was also shown by Navez et al. [19]. In contrast, patients with previous colectomies were more likely to be treated with open surgery. This attitude may go back to the early days of laparoscopic surgery when previous major abdominal interventions were looked upon very critically and cautionary voices consistently and repeatedly warned against MIS under these circumstances [20]. The historic argument for this approach is the formation of dense adhesions, which is thought to progress with each subsequent procedure [21]. Van der Krabben et al. revealed a tenfold increase in the enterotomy rate in patients with three or more previous laparotomies in the year 2000 [22]. Also León et al. concluded that extensive dense adhesion formation should be seen as a contraindication to the MIS approach [23]. In a cohort of 8584 patients who were undergoing surgery for ABO between 2005 and 2014, Behman et al. revealed that laparoscopic surgery for ABO showed a higher possibility for bowel injury [24].

However, more recent data emphasize the use of MIS techniques in patients with previous abdominal surgery. The LASSO trial, an international, multicenter, parallel, open-label trial, where 104 patients with ABO were randomly assigned to undergo either MIS or OS, revealed no difference between the two surgical groups concerning iatrogenic bowel injury [25]. Moreover, the feasibility and safety of minimally invasive redo-surgery has been shown for procedures in multiple-organ systems including hepato-pancreatic-biliary resections [26, 27] and colorectal resections [28]. In this respect again, a preconceived opinion might be prevalent and surgeons abide by their trained behaviors.

The findings made in our study also suggest a decreased willingness to perform MIS when bowel width increases or when a tumor is the cause of the obstruction. In these cases, MIS may be hampered because of a poorer overview in the abdominal cavity and a higher risk of bowel injury [29]. Suter et al. reported that a bowel diameter exceeding 4 cm was associated with an increased rate of conversion to OS [30]. This argument appears to be valid. However, it is also based on data from the early days of MIS, when only patients with a bowel dilatation of less than 4 cm and a partial obstruction were considered eligible for laparoscopic interventions [31]. In more recent studies [32] no association between loop width and complications was reported. This is supported by the fact that measurement of bowel width is difficult in patients with bowel obstruction and the usually indicated maximum diameter does not allow conclusions on the affected overall bowel capacity.

A tumor as the cause of small-bowel obstruction (SBO) resulted in OS significantly more often in our study. The possible limitations in handling the specimen and performing a good lymphadenectomy may cause this reluctance. However, the available meta-analysis data do not indicate SBO as a contraindication for MIS in patients with a small-bowel tumor [33]. Moreover, the data in the above-mentioned
meta-analysis reveal that SBO was never a reason for conversion in these cases.

It is important to note that some unconventional parameters contributed to the decision on surgical strategy:

Firstly, a late admission time resulted in significantly more open procedures in our series. These findings are in line with those of Zimmermann et al., who reported on a large survey among German surgeons. Willingness to perform MIS decreased with the expected late time for surgery in their series due to a possible lack of expertise in the emergency situation when on duty at night [12]. In contrast to this point, a lack of expertise, expressed as the non-availability of an experienced assisting surgeon, was not a reason to decide against a MIS procedure in our results. However, late admission time represents emergency surgery outside the pre-planned schedule with possibly hampered procedural flow. This is in accordance with the above-mentioned survey showing that a prolongation of the procedural time, again, deters almost 40% of the interviewed surgeons from a MIS approach. This factor may have also been a key reason for this decision in our series. However, underpinned by this and other afore-referenced data, there may not be any sound medical justification for this approach.

Secondly, no difference in the surgical approach was seen when senior surgeons or residents under supervision performed the procedure. This may indicate a patient-centered decision process rather than a surgeon-centered process. Moreover, this expresses a high degree of confidence in residents’ abilities, which encourages us to continue our progressive approach to teaching MIS to the next generation of surgeons.

Thirdly, the availability of an assisting resident surgeon with experience in general surgery (training years 1–6) or an assisting senior surgeon, rather than a decision to perform the procedure with a junior doctor with no experience in general surgery, had no influence on the decision-making process. At least in terms of the number of adverse intra-operative events, it is known that a lower complication rate reflects the main surgeon’s experience, but does not show any relation to the experience of the assisting resident [34]. This may confirm the assumption that the process of deciding for a particular surgical strategy depends mainly on the knowledge, skills, and decisions of the responsible surgeon.

As all our surgeons are enthusiastic SIL surgeons and the technique was included in our clinical routine in 2009 with a number of 6000 different surgical procedures, a subgroup analysis of these procedures was performed. This revealed no difference in any respect when compared to the MPL group. This corresponds to the findings of Hiro et al. [35] and validates the fact that SIL surgery can be regarded as an evolution of MIS that does not shift its indications or limitations, but reduces the incisional trauma with all its advantages and disadvantages.

Limitations

Even if all consecutive SBO patients in the study period were included in this series, no ASA score higher than 3 was assigned by the anesthesiologist. Due to the retrospective character of this study, no further verification of this fact is possible.

The timespan of the study period from 2009 to 2017 and publication in 2022 can be regarded as a limitation. This is due to the beginning of the COVID-19 pandemic in 2019 when clinical habits and treatment pathways underwent sudden significant changes. Thus, further inclusion of patients during the pandemic would have biased the study population as a result of strategic alterations in this exceptional situation.

The retrospective design of this study could be seen as a limitation. However, the decisions already been made can be used to elaborate confounders.

The herein presented results may not apply for all teaching hospitals, as general guidelines and policies are usually given by the clinical director.

Conclusions

In conclusion, it can be stated that the reasons for applying MIS or OS in patients with acute bowel obstruction are manifold. Despite the current understanding of internal hospital guidelines or very basic patient factors (such as BMI or age), our study revealed unconventional parameters that influence the decision for or against a particular surgical strategy.

Consequently, as some of these strategies are refuted nowadays, a change to MIS as the approach of choice with a realistic threshold to conversion could give more patients access to the benefits of MIS.

Abbreviations

MD: Medical doctor; ABO: Acute bowel obstruction; MIS: Minimally invasive surgery; OS: Open surgery; LOS: Length of stay; GI: Gastrointestinal; ASA: American Society of Anaesthesiologists; ICD: International Statistical Classification of Diseases and Related Health Problems; WA: Washington; USA: United States of America; MPL: Multiport laparoscopy; SIL: Single-incision laparoscopy; BMI: Body mass index; AE: Appendectomy; CRP: C-reactive protein; OR: Odds ratio; CI: Confidence interval; LASSO: Laparoscopic versus open adhesiolysis for adhesive small-bowel obstruction; SBO: Small-bowel obstruction; EKS: Ethikkommission Salzburg

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Authors’ contributions H. H. collected and interpreted the data, drafted, and wrote the manuscript. M. G., P. P., and M. D. C. interpreted the data. T. H. analyzed the data. H. W. and C. M. designed the study, interpreted the data, and wrote the manuscript. All authors have approved the submitted manuscript and agree to be personally accountable for their own contributions and ensure that questions related to the
accuracy or integrity of any part of the work are appropriately investigated, resolved, and that the resolution is documented in the literature.

Data availability The datasets generated and analyzed during the current study are not publicly available due to hospital policy but are available from the corresponding author on reasonable request.

Declarations

Ethics approval The study was approved by the local ethical committee, Ethikkommission Salzburg (EKS), Number 1029/2020.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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