Research Square

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Waiting 12 h or more for appendicectomy is associated with worse operative findings: a retrospective cohort study of 909 adults

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Abstract

Purpose

Urgent appendicectomy assumes that waiting lets appendicitis progress. We examined whether in-hospital delay is associated with worse operative findings and morbidity.

Methods

Retrospective cohort of consecutive adults undergoing emergency laparoscopic appendicectomy at a tertiary centre (2017–2021). The exposure was in-hospital delay, the protocol-defined interval from surgical request to skin incision, categorised as < 12 h, 12–24 h and > 24 h. The primary outcome was intraoperative progression: complicated appendicitis at operation in patients whose preoperative imaging was uncomplicated. Secondary outcomes were 30-day morbidity (Clavien–Dindo) and readmission. Models were adjusted only for variables fixed before the delay.

Results

Of 909 patients (median age 37 years, 52.5% men), median delay was 3.4 h and 811 (89.2%) were operated on within 12 h. Imaging and operative findings agreed in 675 (74.3%); in 217 (23.9%) uncomplicated imaging proved complicated. Among the 712 patients with uncomplicated imaging, waiting 12 h or more was associated with progression (40% vs 29.1%; adjusted odds ratio [OR] 1.87, 95% confidence interval [CI] 1.14–3.06; p = 0.013); below that threshold delay had no effect (OR 0.90 per 6 h, 0.61–1.34). The delay groups were comparable in all baseline variables (p ≥ 0.14). Delay was not associated with 30-day morbidity (OR 0.91, 0.39–2.10), which depended on radiological severity, comorbidity and male sex.

Conclusion

Waiting 12 h or more was associated with finding complicated appendicitis more often, without more morbidity; with only 98 patients beyond that threshold, a small excess cannot be excluded. These data support same-day appendicectomy and a 12 h limit for intervention.

Introduction

Acute appendicitis is one of the most frequent indications for emergency abdominal surgery [1]. Management long rested on the premise that inflammation progresses inexorably to perforation, so that every hour of waiting adds risk. That premise has been revised: two forms with distinct natural histories are now recognised, uncomplicated and complicated appendicitis, and only the second reliably

progresses [2]. Laparoscopic appendicectomy remains the standard treatment [3, 4], with antibiotics an alternative in selected patients [5, 6].

How much delay is acceptable once surgery has been indicated remains unsettled, and the question is practical: theatre capacity is limited, and the surgeon on call must decide whether a stable patient diagnosed at night is operated on at once or added to the morning list. Published answers conflict. Some studies find no increase in complications within the first 24 h [7]; one national cohort found more complications and deaths beyond that point [8]; others link delay to surgical site infection [9] or to complicated appendicitis [10, 11]. Recent meta-analyses using 8–12 h cut-offs found no difference in morbidity [12, 13], and the 2025 guidelines of the World Society of Emergency Surgery (WSES) accept a delay of up to 24 h in uncomplicated disease [3].

Part of the discrepancy comes from conflating two questions: whether waiting worsens the appendix, and whether it worsens the patient. The two need not coincide, since modern perioperative care may contain the consequences of more advanced disease. A recent natural-history study found that perforation tracks symptom duration rather than time since admission [14]. Our hypothesis was that in-hospital delay worsens both the operative findings and postoperative morbidity, and we analysed the two separately in a consecutive cohort.

Methods

Design and setting

Retrospective cohort study in the Department of General and Digestive Surgery of Hospital Universitari Vall d'Hebron, Barcelona, a tertiary centre with a 24 h emergency surgery service. Reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [15].

Participants

The hospital information system identified admissions between 1 January 2017 and 31 December 2021 coded as acute appendicitis with a laparoscopic appendicectomy: 1941 episodes in 1927 patients. We excluded patients under 18 years, cases without confirmed acute appendicitis, elective and interval appendicectomies, duplicate records, and cases in which exposure or outcome could not be established, leaving 909 patients (Fig. 1). Counts for each individual exclusion criterion were not retained. The 909 analysed did not differ from the 381 screened adults who were not analysed in age ($p = 0.11$), sex ($p = 0.77$) or postoperative stay ($p = 0.75$).

Exposure

The exposure was in-hospital delay: the minutes between the surgeon's request for operation and skin incision, both taken from the theatre record. It excludes prehospital and diagnostic time. It was analysed

in the prespecified categories of less than 12 h, 12–24 h and more than 24 h, and as a continuous variable. The operating shift was taken from the time of incision: morning (08.00–15.00 h), afternoon (15.00–22.00 h) and night (22.00–08.00 h).

Outcomes and rationale for the analysis subgroup

Severity was classified following the WSES framework and published grading systems [3, 16]: complicated with perforation, purulent peritonitis, intra-abdominal abscess or extraluminal faecoliths, uncomplicated otherwise. The radiological classification came from the preoperative imaging report, the operative classification from the surgeon's operative note. Neither was re-reviewed, and the surgeon knew how long the patient had waited.

The primary outcome was intraoperative progression: complicated appendicitis at operation in patients whose imaging was uncomplicated, compared with patients in whom both classifications agreed. Progression can only be measured in this subgroup. Where imaging already showed complicated disease there is no room to detect it, and the reverse discordance is test error rather than clinical change.

Secondary outcomes were any complication within 30 days, graded by the Clavien–Dindo classification [17] in the whole cohort, major morbidity (grade IIIa or higher, or death), postoperative stay, 30-day readmission, reoperation, conversion and in-hospital mortality.

Statistical analysis

Continuous variables are expressed as median with interquartile range (IQR) and were compared by the Mann–Whitney U or Kruskal–Wallis test; categorical variables as counts and percentages, compared by the chi-square or Fisher's exact test. Exact p values are given except where below 0.001.

The primary outcome and 30-day morbidity were analysed by multivariable logistic regression, adjusted for age, sex, Charlson Comorbidity Index (CCI) [18] and prehospital symptom duration, and for radiological severity in the morbidity model. All of these are fixed before the delay. We did not adjust for intraoperative severity or operative time, which are measured afterwards and may be consequences of the delay. Adjusted models were fitted only for outcomes with at least 40 events.

Complications were recorded in a dedicated field, and the Clavien–Dindo grade only for patients with a complication. Two patients had a recorded complication without a grade and were assigned grade I; one recorded as grade 0 was analysed as free of complications; the three in-hospital deaths were assigned grade V. Missing values for conversion (n = 1) and mortality (n = 2) were analysed as absent events. No other variable had missing data, and no imputation was performed.

Both analyses were repeated excluding patients who waited more than 24 h and adding the operating shift. A two-sided p value below 0.05 was considered significant. Analyses used IBM SPSS Statistics

version 23 (IBM Corp., Armonk, NY, USA).

Literature searching was assisted by Claude Opus 5.5 (Anthropic PBC, San Francisco, CA, USA). All retrieved records were verified by the authors against the original publications in PubMed. No AI tool was used to generate or format references.

Results

Cohort and distribution of delay

Of 1941 screened episodes, 909 patients were analysed (Fig. 1): median age 37 years (IQR 27–53), 477 men (52.5%). Median prehospital symptom duration was 24 h (Table 1). Eighty-two patients (9.0%) had a postoperative complication, 25 (2.8%) a major one, and three died (0.3%), all over 70 years with a CCI of 6 or more.

Table 1
Cohort characteristics

Characteristic	All patients (n = 909)	Uncomplicated imaging (n = 712)
Age, years, median (IQR)	37 (27–53)	36 (26–50)
Age ≥ 65 years, n (%)	107 (11.8)	68 (9.6)
Male sex, n (%)	477 (52.5)	374 (52.5)
CCI, median (IQR)	0 (0–1)	0 (0–1)
Symptom duration, h, median (IQR)	24 (12–48)	24 (12–48)
In-hospital delay, h, median (IQR)	3.4 (1.9–7.1)	3.6 (2.0–7.6)
Delay < 12 h, n (%)	811 (89.2)	622 (87.4)
Delay 12–24 h, n (%)	87 (9.6)	82 (11.5)
Delay > 24 h, n (%)	11 (1.2)	8 (1.1)
Night surgery, n (%)	265 (29.2)	193 (27.1)
Complicated at operation, n (%)	397 (43.7)	217 (30.5)
Operative time, min, median (IQR)	75 (60–95)	72 (60–90)
Conversion to open surgery, n (%)	11 (1.2)	3 (0.4)
30-day morbidity, n (%)	82 (9.0)	49 (6.9)
Major morbidity, n (%)	25 (2.8)	13 (1.8)
30-day readmission, n (%)	30 (3.3)	20 (2.8)
Postoperative stay, days, median (IQR)	2 (1–3)	2 (1–2)
Mortality, n (%)	3 (0.3)	1 (0.1)

CCI, Charlson Comorbidity Index; IQR, interquartile range. The right-hand column is the subgroup in which the primary outcome was analysed.

Median delay was 3.4 h (IQR 1.9–7.1): 811 patients (89.2%) were operated on within 12 h, 87 (9.6%) between 12 and 24 h, and 11 (1.2%) later.

Agreement between imaging and operative findings

The two classifications agreed in 675 patients (74.3%). In 217 (23.9%) uncomplicated imaging proved complicated at operation, in 180 (19.8%) complicated imaging was confirmed, and in 17 (1.9%) the reverse occurred (Table 2).

Table 2
Agreement between the radiological classification and the operative findings

Group	n (%)	Delay, h, median (IQR)	Delay ≥ 12 h	Age	Symptoms, h
Concordant uncomplicated	495 (54.5)	3.4 (1.9–7.3)	10.9%	33	24
Progression (uncomplicated imaging → complicated at operation)	217 (23.9)	3.9 (2.1–8.6)	16.6%	46	24
Concordant complicated	180 (19.8)	2.8 (1.8–4.8)	3.9%	46	48
Overcall (complicated imaging → uncomplicated at operation)	17 (1.9)	2.7 (1.6–5.7)	5.9%	38	36

IQR, interquartile range. Age and symptom duration are medians. Delay across the four groups p = 0.004 (Kruskal–Wallis); proportion waiting ≥ 12 h p = 0.002 (exact test).

Delay differed across the four groups (p = 0.004), reflecting triage: patients whose imaging already showed complicated disease were operated on sooner (median 2.8 vs 3.4 h). Progression is therefore analysed only in those with uncomplicated imaging.

Delay and intraoperative progression

Of the 712 patients with uncomplicated imaging, 217 (30.5%) proved complicated at operation. They were older (median 46 vs 33 years), more often male, and had waited longer (3.9 vs 3.4 h, p = 0.16). Their symptoms had lasted longer on univariable comparison (24 [18–48] vs 24 [12–24] h; p < 0.001), but not after adjustment for age (Table 3).

Table 3
Factors associated with intraoperative progression among patients with uncomplicated preoperative imaging (n = 712; 217 events)

Variable	No progression (n = 495)	Progression (n = 217)	p	Adjusted OR (95% CI)
Age, years, median (IQR)	33 (25–44)	46 (32–62)	< 0.001*	1.66 (1.40–1.96) per decade
Male sex, n (%)	245 (49.5)	129 (59.4)	0.018*	1.68 (1.19–2.38)
CCI, median (IQR)	0 (0–0)	0 (0–2)	< 0.001*	0.91 (0.77–1.08) per point
Symptom duration, h, median (IQR)	24 (12–24)	24 (18–48)	< 0.001*	1.04 (0.98–1.11) per 12 h
Delay, h, median (IQR)	3.4 (1.9–7.3)	3.9 (2.1–8.6)	0.160	—
Delay ≥ 12 h, n (%)	54 (10.9)	36 (16.6)	0.048*	1.87 (1.14–3.06)
Night surgery, n (%)	138 (27.9)	55 (25.3)	0.543	—

CCI, Charlson Comorbidity Index; CI, confidence interval; IQR, interquartile range; OR, odds ratio. * p < 0.05. Univariable comparisons by Mann–Whitney U or chi-square test. The multivariable model comprises the five variables with an estimate in the last column.

Progression rose from 29.1% within 12 h to 40% beyond. Waiting 12 h or more was associated with progression (adjusted odds ratio [OR] 1.87, 95% confidence interval [CI] 1.14–3.06; p = 0.013), as were age (OR 1.66 per decade, 1.40–1.96) and male sex (OR 1.68, 1.19–2.38). Below 12 h, delay had no effect (OR 0.90 per 6 h, 0.61–1.34; p = 0.61): the relationship is a threshold, not a gradual rise.

The two delay groups were comparable in age (median 36 vs 35 years; p = 0.70), comorbidity (p = 0.50), symptom duration (p = 0.14), sex (p = 0.39) and night surgery (p = 0.14).

Delay and postoperative morbidity

Waiting 12 h or more was not associated with 30-day morbidity, major morbidity, readmission, conversion or hospital stay, in the whole cohort or in the uncomplicated-imaging subgroup (Table 4). As a continuous variable delay was likewise unassociated (OR 0.88 per 6 h, 95% CI 0.65–1.20). Morbidity depended on radiological severity (OR 1.93, 1.14–3.26), the CCI (OR 1.28 per point, 1.08–1.50) and male sex (OR 1.91, 1.16–3.14) (Table 5).

Table 4
Outcomes according to in-hospital delay

Outcome	Delay < 12 h	Delay ≥ 12 h	Adjusted OR (95% CI) or p
Subgroup with uncomplicated imaging	**n = 622**	**n = 90**	
Complicated appendicitis at operation	181 (29.1%)	36 (40.0%)	1.87 (1.14–3.06)*
30-day morbidity	43 (6.9%)	6 (6.7%)	0.98 (0.40–2.44)
Major morbidity	11 (1.8%)	2 (2.2%)	p = 0.67
30-day readmission	17 (2.7%)	3 (3.3%)	p = 0.73
Postoperative stay, days, median (IQR)	2 (1–2)	2 (1–3)	p = 0.21
Whole cohort	**n = 811**	**n = 98**	
30-day morbidity	75 (9.2%)	7 (7.1%)	0.91 (0.39–2.10)
Major morbidity	23 (2.8%)	2 (2.0%)	p = 1.00
30-day readmission	27 (3.3%)	3 (3.1%)	p = 1.00
Conversion to open surgery	11 (1.4%)	0 (0.0%)	p = 0.62
Postoperative stay, days, median (IQR)	2 (1–3)	2 (1–3)	p = 0.67

CCI, Charlson Comorbidity Index; CI, confidence interval; IQR, interquartile range; OR, odds ratio. * p < 0.05. Adjusted models (age, sex, CCI and symptom duration, plus radiological severity in the whole cohort) were fitted only for outcomes with at least 40 events; crude comparisons by Fisher's exact test, or Mann–Whitney U for stay.

Table 5
Factors associated with 30-day postoperative morbidity (n = 909; 82 events)

Variable	Adjusted OR (95% CI)	p
Delay ≥ 12 h	0.91 (0.39–2.10)	0.82
Age, per decade	1.02 (0.84–1.24)	0.85
Male sex	1.91 (1.16–3.14)	0.011*
CCI, per point	1.28 (1.08–1.50)	0.003*
Symptom duration, per 12 h	1.04 (0.97–1.11)	0.28
Radiologically complicated appendicitis	1.93 (1.14–3.26)	0.014*

CCI, Charlson Comorbidity Index; CI, confidence interval; OR, odds ratio. * p < 0.05.

Progression itself did carry consequences: among patients with uncomplicated imaging, those complicated at operation had more complications (14.7% vs 3.4%; $p < 0.001$), more readmissions (6.9% vs 1.0%) and a median stay of 3 vs 1 day.

Operating shift and sensitivity analyses

The operating shift was not associated with morbidity (morning 6.6%, afternoon 11.1%, night 8.7%; $p = 0.38$ adjusted). Results held when patients who waited more than 24 h were excluded (progression OR 1.89, 95% CI 1.13–3.15; morbidity OR 1.08, 0.46–2.53) and when the shift was added (progression OR 1.86, 1.13–3.04).

Discussion

Among 909 adults undergoing emergency laparoscopic appendicectomy, waiting 12 h or more was associated with finding complicated appendicitis more often, but not with more postoperative morbidity. Below that threshold, delay was associated with neither. The proposed hypothesis is therefore supported only in part, and only beyond a point.

The two results are not in conflict. What worsens with waiting is the operative finding, and complicated appendicitis does carry worse outcomes: in our cohort, more complications, more readmissions and a longer stay. But only 98 patients waited 12 h or more, and in a group that size the resulting excess morbidity falls below what we could detect. We cannot say waiting is harmless, only that we found no harm.

This helps reconcile an apparently contradictory literature. The studies reporting no effect compared broad intervals within the first 24 h: a meta-analysis of 152 314 patients gave pooled adjusted odds ratios for complicated appendicitis of 1.07 at 7–12 h and 1.09 at 13–24 h [7], and large series of postoperative complications agreed [19–21]. Associations appear at later boundaries: complicated appendicitis beyond 12 h in 2943 patients (OR 1.41, 95% CI 1.14–1.75) [11]; perforation rising from 9.5% to 18.9% beyond 12 h [10]; and more complications and deaths beyond 24 h in a national cohort [8] and a case-crossover study of 25 874 patients [20]. A recent meta-analysis gave a pooled odds ratio for perforation in adults of 1.29 (1.00–1.67) [12], while a smaller one using an 8 h cut-off found none [13]. Our result fits that pattern: nothing below 12 h, an association beyond it.

Restricting the comparison to uncomplicated imaging means all patients started from the same classification, known before the delay, and those who waited 12 h or more did not differ in age, comorbidity, sex, shift or symptom duration. Symptom duration, which tracks perforation in natural-history data [14], was longer in those who progressed, but not independently of age. The main alternative explanation is misclassification: ultrasound, our first-line test, discriminates complicated from uncomplicated appendicitis poorly — 26% sensitivity in adults in a nationwide series [22], no poolable estimate in a meta-analysis of accuracy [23] — so some of the 217 patients were probably complicated

from the start. That the association appears as a threshold at 12 h, rather than rising gradually, argues against misclassification explaining all of it, but an observational design cannot separate the two.

For an emergency service the implication is concrete. The operating shift was not associated with morbidity, as in the Swiss national cohort [8] and two recent series [24, 25], so a stable patient diagnosed at night can wait for the morning list. What these data question is leaving that wait open: the 2025 WSES guidelines accept up to 24 h on the basis of postoperative outcomes [3], which our morbidity data match, but our operative findings suggest the appendix deteriorates earlier, and we would treat 12 h as a limit for intervention. Imaging cannot pick who may safely wait: almost a third of uncomplicated scans were complicated at operation, consistent with its poor discrimination in routine practice [22], though dedicated computed tomography (CT) series do better [26].

The limitations are those of a retrospective single-centre design. Residual confounding cannot be excluded: American Society of Anesthesiologists (ASA) class, admission C-reactive protein — an established predictor of complicated appendicitis here [10] — white cell count and the timing of preoperative antibiotics were not retrievable. Only 98 patients waited 12 h or more and 11 more than 24 h, so estimates at those margins are imprecise, and the period includes 2020–2021. Against this, the cohort is large and consecutive, management was homogeneous, the exposure was protocol-defined, and the comparison rests on the temporal order of the variables.

Confirmation would require a prospective study assigning stable patients with radiologically uncomplicated appendicitis to immediate or next-morning surgery, with the operative findings as a prespecified outcome alongside morbidity and the imaging read independently.

Conclusion

Waiting 12 h or more for appendicectomy was associated with finding complicated appendicitis more often in patients whose preoperative imaging was uncomplicated. Below that threshold, delay was associated with neither worse findings nor more morbidity, which depended on radiological severity, comorbidity and male sex.

We did not detect more morbidity with delay, but had no power to exclude it. In practice these data support operating within the same day and treating 12 h as a limit for intervention, not a flexible margin.

Declarations

Competing interests:

The authors declare that they have no competing interests.

Ethics approval:

The study was approved by the Comitè d'Ètica d'Investigació amb Medicaments of Hospital Universitari Vall d'Hebron, Barcelona (reference PR(AG)448/2022), and was conducted in accordance with the Declaration of Helsinki, Regulation (EU) 2016/679 and Spanish Organic Law 3/2018.

Consent to participate:

The ethics committee waived the requirement for written informed consent because the study was a retrospective review of coded clinical records with no intervention and no patient-identifiable data.

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Author Contribution

C.P.C. and A.G.G. conceived and designed the study. M.M.-L. and S.V. collected the data. M.M.-L. and C.P.C. performed the statistical analysis. M.M.-L. wrote the main manuscript text. A.G.G., C.P.C. and J.L.S.G. revised the manuscript critically for important intellectual content. All authors reviewed and approved the final manuscript.

Data Availability

The data that support the findings of this study are not publicly available because they are coded clinical records whose release is restricted by the institutional data protection approval under which they were collected. The coded database will be retained for five years and is available from the corresponding author on reasonable request, subject to that approval.

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Figures

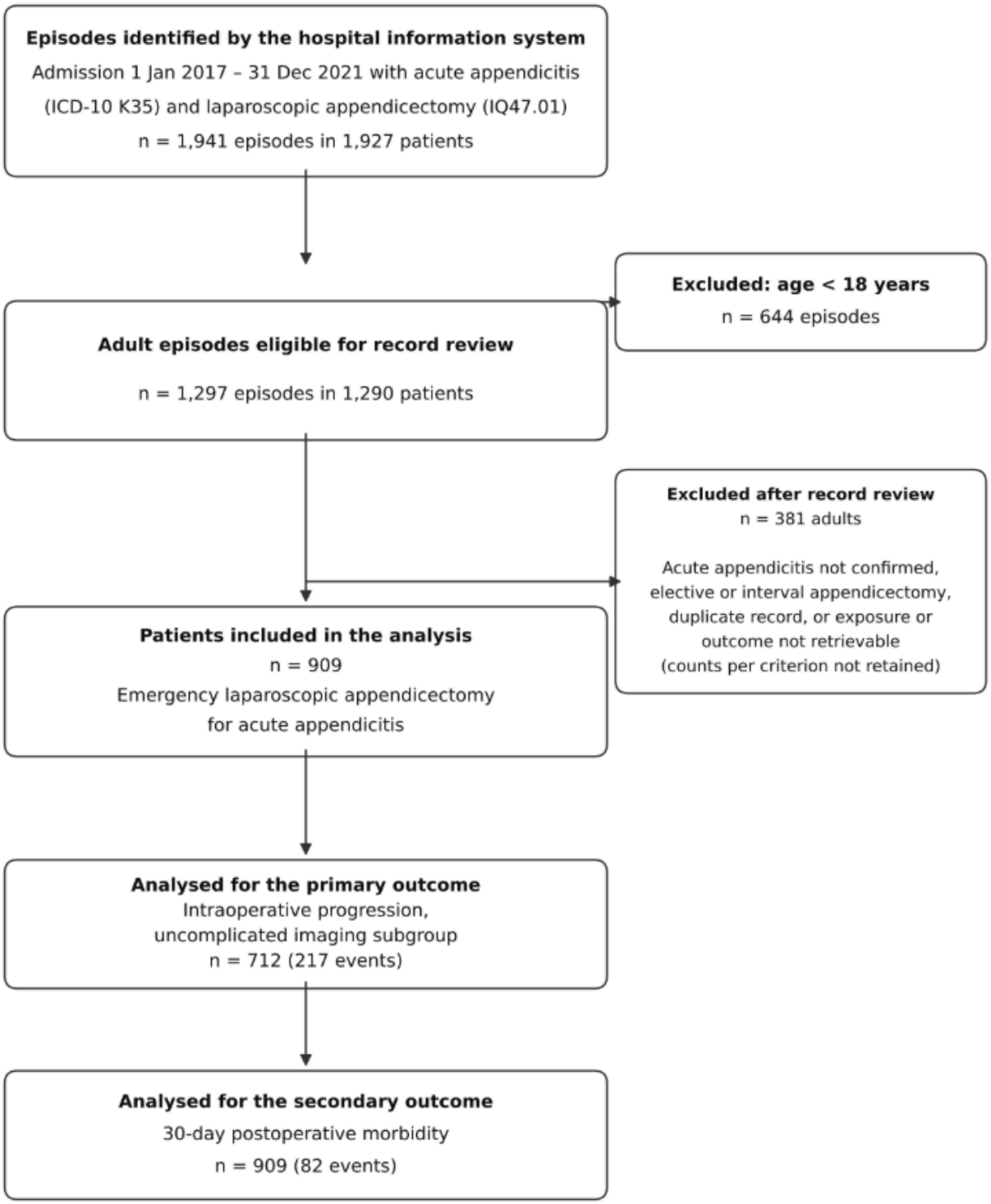


Figure 1

Flow of patients through the study

Supplementary Files

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- STROBEchecklist.docx