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Assessing gastric contents in children before general anesthesia for acute extremity fracture: an ultrasound observational cohort study

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Jean-Noël Evain, Zoé Durand, Kelly Dilworth, Sarah Sintzel, Aurélien Courvoisier, Guillaume Mortamet, François-Pierrick Desgranges, Lionel Bouvet, and Jean-François Payen declare that they have no conflict of interest. This study was solely supported by institutional funding. No grants were received from any funding agencies in the public, commercial, or non-profit sectors.

1 **Abstract**

2 **Study objective:** Children with acute extremity fractures are commonly considered to be at
3 risk of pulmonary aspiration of gastric contents during the induction of anesthesia. This study
4 aimed to evaluate the proportion of such children with high-risk gastric contents using
5 preoperative gastric ultrasound.

6 **Design:** Prospective observational cohort study.

7 **Setting:** Specialist pediatric center over a 30-month period.

8 **Patients:** Children undergoing surgery within 24 hours of an acute extremity fracture.

9 **Interventions:** None.

10 **Measurements:** According to preoperative qualitative and quantitative ultrasound analysis of
11 the antrum in the supine and right lateral decubitus positions, gastric contents were classified
12 as high-risk (clear liquid with calculated gastric fluid volume $>0.8 \text{ ml.kg}^{-1}$, thick liquid, or
13 solid) or low-risk. Factors associated with high-risk gastric contents were identified by
14 multivariable analysis.

15 **Main results:** Forty-one children (37%; 95% CI: 28-47) of the 110 studied (mean(SD) age:
16 10(3) years) presented with high-risk gastric contents, including 26 (24%; 95% CI: 16-33)
17 with solids/thick liquid contents. Scanning in the supine position alone allowed a diagnosis of
18 high-risk gastric contents in 23 children out of the 63 for whom right lateral decubitus
19 positioning was unfeasible. Gastric contents remained undetermined in 41 children, including
20 one with a non-contributory gastric US (antrum non-visualized). Proximal limb fractures
21 (OR: 2.5; 95% CI: 1.0-6.2), preoperative administration of opioids (OR: 3.9; 95% CI: 1.1-13),
22 and the absence of bowel sounds (OR: 8.0; 95% CI: 1.4-44) were associated with high-risk
23 gastric contents. Performing surgery the day following the trauma was a protective factor
24 (OR: 0.1; 95% CI: 0.0-0.6). No cases of pulmonary aspiration occurred.

25 **Conclusions:** At least one-third of children with an acute isolated extremity fracture had
26 preoperative gastric contents identified as high risk for pulmonary aspiration. Although
27 preoperative history can guide anesthetic strategy in this population, ultrasound allowed clear
28 stratification of the risk of aspiration in most cases.

29 **Keywords:** anesthesia, pediatrics, bone fracture, bronchopulmonary aspiration, gastric
30 ultrasound

31 **1. Introduction**

32 Extremity fractures are the most common type of pediatric orthopedic emergency [1]. General
33 anesthesia is often required for closed reduction of such fractures, and is indicated for the vast
34 majority of internal fixation procedures. Regardless of the duration of pre-operative fasting,
35 children with an acute extremity fracture have conventionally been considered to have gastric
36 contents constituting a significant risk of bronchopulmonary aspiration during the induction
37 of general anesthesia [2–4]. This hypothesis is based on the risk of delayed gastric emptying
38 due to the potential reduction in gastrointestinal peristalsis associated with acute stress and
39 pain [5,6], which may be further aggravated by the administration of opioid analgesics [7]. To
40 minimize the risk of aspiration, a rapid sequence induction with administration of a rapid-
41 onset neuromuscular blocking agent (NMBA) is frequently used for induction of general
42 anesthesia and tracheal intubation. Undertaking rapid sequence induction, however, exposes
43 children to other complications such as hypoxemia, difficult intubation, and NMBA-related
44 major allergic reactions [8]. Given the low incidence and rare morbidity of pulmonary
45 aspiration in children [9–11], rapid sequence induction (as performed in adults) has been
46 called into question in pediatric anesthesia [12,13].

47 Gastric antral ultrasound (US), a relatively new application of point-of-care US, is a
48 simple, non-invasive and non-irradiating imaging technique that allows a reliable and rapid
49 assessment of gastric contents [14]. It can be performed routinely at the bed-side just before
50 anesthesia for emergency pediatric surgery [15,16]. The results of gastric US assessment can
51 help to determine the anesthetic strategy for an individual patient, in particular whether or not
52 rapid sequence induction is warranted [16,17]. The **upcoming** European recommendations on
53 preoperative fasting in children suggest assessing gastric contents with US in children before
54 emergency surgery (Grade 2C) [18]. As a research tool, gastric US has the potential to

55 improve our knowledge of the incidence of high-risk gastric contents in different patient
56 populations and clinical scenarios, and thereby identify possible predictive factors [19,20].

57 Limited data exists on the prevalence of, and predictive factors for high-risk gastric
58 contents in children presenting to the operating room with an acute extremity fracture. Point-
59 of-care antral US examination upon arrival in the operating room is a customary practice in
60 our department. Using qualitative and quantitative US examination of the gastric antrum, we
61 performed a prospective observational study with the aim of estimating the percentage of
62 children requiring a general anesthesia for an acute extremity fracture who had gastric
63 contents considered to infer a higher risk of pulmonary aspiration. The secondary objective
64 was to identify independent factors associated with high-risk gastric contents in this
65 population.

66

67 2. Materials and Methods

68 2.1. Study population and setting

69 This single-center observational cohort study was conducted in the pediatric theater suite of
70 our University Hospital between November, 2018 and April, 2021. Based on operator
71 availability, we collected data from patients under 18 years of age immediately prior to
72 general anesthesia for urgent (<8h) or semi-urgent (8-24h) closed reduction and/or internal
73 fixation of a recent long-bone traumatic fracture of the lower or upper extremities (humerus,
74 radius, ulna, femur, tibia, or fibula). The exclusion criteria were: delay between traumatism
75 and entry into operating room greater than 24 hours, multiple trauma, and re-operation. In
76 accordance with French legislation [21], routine clinical data were prospectively recorded in
77 the subjects' medical records, **without necessitating prior Clinical Trial registration**. Children
78 and their legal guardians were informed about the study and had the opportunity to revoke
79 their permission for the use and disclosure of protected health information. The absence of
80 ethical issues was confirmed by the Ethics Committee of the French Society of Anesthesia &
81 Intensive Care Medicine (Institutional Review Board number 00010254-2021-038) on March
82 15, 2021, allowing the data to be anonymized, pooled, and analyzed from May to July 2021.
83 The methodology followed the recommendations of the Strengthening the Reporting of
84 Observational studies in Epidemiology statement [22].

85 2.2. Preoperative gastric ultrasound examination

86 US examination was performed just before induction of general anesthesia, either in the
87 patient transfer area or in the operating room by a trained operator (JNE or KD, two pediatric
88 anesthesiologists experienced in gastric US), using an S-NerveTM or M-TurboTM machine (Fujifilm
89 Sonosite, Bothell, USA) and a low frequency (2–5 MHz) convex abdominal probe. The
90 gastric antrum was visualized in a standardized sagittal or slightly para-sagittal plane in the

91 epigastrium, located posterior to the liver and anterior to the pancreas, abdominal aorta and/or
92 the inferior vena cava [14]. The US examination was initially performed in the supine
93 position, and subsequently whenever feasible, in the right lateral decubitus (RLD) position. In
94 each position, gastric antral contents were assessed qualitatively as empty, clear liquid, or
95 solid/thick liquid. In the presence of clear liquid in the RLD position, the maximum (D) and
96 minimum (d) perpendicular diameters of the antral section were measured to calculate the
97 cross sectional area (CSA) using the formula for the area of an ellipse ($CSA \text{ (mm}^2\text{)} =$
98 $d \cdot D \cdot \pi / 4$) [14]. Gastric fluid volume (GFV) was subsequently calculated using a
99 mathematical model validated in the pediatric population ($GFV \text{ (ml.kg}^{-1}\text{)} = [0.035 \cdot CSA +$
100 $1.52 \cdot \text{age (years)} - 7.8] / \text{body weight (kg)}$) [23].

101 2.3. Primary endpoint

102 The primary endpoint was the determination of children with preoperative gastric
103 contents constituting an increased risk of pulmonary aspiration. The risk of pulmonary
104 aspiration associated with gastric contents was categorized according to the findings on
105 gastric US [15]:

106 - High-risk gastric contents were defined by the presence of solid/thick liquid contents
107 (whatever the position), or when a significant volume of clear liquid was measured ($GFV >$
108 0.8 mL.kg^{-1}) or evoked (RLD position infeasible due to pain but clear liquid content visible in
109 the supine position).

110 - Low-risk gastric contents were defined by the presence of an empty antrum in both
111 the supine and RLD positions or when a small volume of clear liquid content was present in
112 the RLD position ($GFV < 0.8 \text{ mL.kg}^{-1}$). As the threshold of GFV above which the aspiration
113 risk becomes significant remains unclear in the literature [16,24], we also utilized a higher
114 threshold (1.5 mL.kg^{-1}) for secondary analysis.

115 - Gastric contents were categorized as indeterminate if the antrum was not seen (US
116 non-contributory), or when the antrum was empty in the supine position and the RLD position
117 was infeasible.

118 2.4. Other data collected

119 Potential factors associated with high-risk gastric contents, determined on the basis of the
120 available literature and the authors' clinical experience, were recorded. These factors included
121 certain demographic variables (gender, age, and weight) and details of the patient's medical
122 history (time the trauma occurred, localization of injury in proximal versus distal segment of
123 the limb, last intake of solids and clear fluids, occurrence of nausea and vomiting, whether
124 opioid or non-opioid analgesics were administered). Other factors documented were specific
125 clinical findings on arrival to the operating room (intensity of pain and absence/presence of
126 bowel sounds). Pain intensity was self-reported whenever possible using the Colour Analog
127 Scale (age < 7 years) or the Numerical Rating Scale (age > 7 years) [25]. The Face Leg
128 Activity Cry Consolability hetero-evaluation scale was used if auto-evaluation was not
129 possible [26]. **The choice of airway control device and whether or not a rapid sequence**
130 **induction was performed (involving the virtually simultaneous administration of an anesthetic**
131 **agent and a rapid-onset NMBA) were also recorded**, as well as the occurrence of
132 regurgitation, pulmonary aspiration, and hypoxemia (defined as SpO₂ < 90% within 10
133 minutes of induction of general anesthesia).

134 2.5. Statistical Analyses

135 Statistical analyses were conducted with XLstat[®] 2021 software (Addinsoft[®], Paris). A *P*-
136 value of less than 0.05 was considered as statistically significant. Qualitative variables were
137 expressed as a number and percentage. The 95% confidence intervals (95% CI) for the
138 proportions studied were calculated using the Wilson's method with continuity correction. To

139 estimate the proportion of high-risk gastric contents with a level of precision (half of the 95%
140 CI) under 10%, the needed number of children to be included was 102 (worst case scenario
141 where the proportion is 50%). Qualitative variables were compared using the chi-square test
142 or the Fischer exact test, as appropriate. The distribution of quantitative variables was studied
143 by frequency histogram and QQ-plot examination, completed as necessary by the Shapiro
144 Wilk test. Quantitative variables were subsequently presented as mean (standard deviation,
145 SD) or median [interquartile range], and compared with the Student t-test or the Mann
146 Whitney U-test, depending on whether the distribution was normal or not. The determination
147 of variables independently associated with high-risk gastric contents identified on US was
148 performed using logistic regression. Odds ratios (OR) were expressed with a 95% CI. The
149 variables associated with high-risk gastric contents with P -value < 0.2 in univariable analysis
150 were considered for a multivariable analysis. Multi-collinearity between these variables was
151 studied using a multiple correspondence analysis and a principal component analysis for the
152 qualitative and quantitative variables, respectively. When there was a statistical association
153 between two variables, the most clinically relevant was retained. Variables selected for
154 multivariable analysis were subjected to a stepwise descending procedure and those with a P -
155 value < 0.05 were retained in the final predictive model. Given the expectation of less than
156 5% missing data, only patients without missing data were considered in the univariable and
157 multivariable logistic regressions (complete case analysis). The goodness of fit of the
158 multivariable model was assessed using the Hosmer-Lemeshow test, and its predictive value
159 was evaluated using a Receiver Operating Characteristics (ROC) curve.

160 3. Results

161 3.1. Study population

162 Data from 110 children, ranging in age from 1.8 to 16.1 years, were extracted (Figure 1).
163 Demographic variables, details of the patient's medical history, and clinical data are shown in
164 Table 1. The interval between trauma and arrival to the operating room was under 8 hours for
165 55 children out of 110. Median [interquartile range] fasting times for solids and liquids before
166 surgery were 10 [7-13] and 8 [5-10] hours, respectively. Five children had ingested clear
167 liquids less than two hours before surgery, and 12 children had consumed food in the 6 hours
168 preceding surgery. Twenty-five children ate solids after their trauma, either before admission
169 (n=6) or following hospitalization on the surgical ward (since surgery was postponed to the
170 next day, n=19). One quarter of the children had an overnight rest between the trauma (before
171 8pm) and the surgery (after 8am the next day).

172 3.2. Incidence of high-risk gastric contents and feasibility of RLD positioning for gastric US

173 The gastric US findings are presented in Figure 2. High-risk gastric contents were found in 41
174 children out of 110 (37%; 95% CI: 28-47), including 26 children (24%; 95% CI 16-33) with
175 solid/thick liquid gastric contents. The proportion of high-risk gastric contents was not
176 significantly different between toddlers, children, and adolescents (2 out of 4, 28 out of 70,
177 and 11 out of 36, respectively; $P=0.54$). Of the 13 children with clear liquid gastric contents
178 in the RLD position, only one had a GFV greater than 1.5 mL.kg^{-1} . Using the higher threshold
179 of 1.5 mL.kg^{-1} , 35 children out of 110 (32%; 95% CI: 24-41) had high-risk gastric contents.
180 The RLD position was feasible for 46 children (42%; 95% CI: 33-52) out of 110. The 63
181 children for whom RLD positioning was unfeasible were more likely to have experienced
182 fractures of the lower limb and/or proximal limb segment (Table 2). In this group,
183 examination in the supine position alone allowed a diagnosis of high-risk gastric contents in

184 23 patients (37%). Gastric contents could not be determined in 41 children, including one
185 with a non-contributory gastric US (antrum non-visualized).

186 3.3. Factors associated with high-risk gastric contents

187 Missing data for potential predictive factors were less than 5%. Children with proximal limb
188 fractures (humerus or femur; OR: 2.5; 95% CI: 1.0-6.2), those receiving opioid analgesics
189 preoperatively (OR: 3.9; 95% CI: 1.1-13), and those with absent bowel sounds (OR: 8.0; 95%
190 CI: 1.4-44) were more likely to have high-risk gastric contents. Conversely, after an overnight
191 interval between trauma and surgery, children were less likely to have high-risk gastric
192 contents (OR: 0.1; 95% CI: 0.0-0.6; Table 3). The area under the ROC curve of the final
193 predictive model was 0.77 (95% CI: 0.68-0.85). Model calibration using the Hosner-
194 Lemershow test for goodness of fit was excellent ($\text{Chi}^2=0.20$, $P=0.98$).

195 3.4. Anesthetic strategy

196 General anesthesia was undertaken for all children within 15 min following the US gastric
197 assessment (no surgery for children with high-risk gastric contents was delayed). **There were**
198 **significant differences in the choice of airway control device and the use of rapid sequence**
199 **induction according to the preoperative gastric contents assessed by US (Table 4).** No cases of
200 regurgitation, pulmonary aspiration of gastric contents, or hypoxemic episodes were observed
201 in this cohort.

202 4. Discussion

203 In this single-center observational study of children with an acute isolated extremity fracture,
204 preoperative point-of-care US found gastric contents associated with a high-risk of pulmonary
205 aspiration in more than one third of patients. Proximal limb fractures, preoperative opioid
206 administration, and the absence of bowel sounds were associated with high-risk gastric
207 contents. Conversely, an overnight rest between trauma and surgery was a protective factor.
208 The performance of gastric US was limited in children for whom RLD positioning was
209 unfeasible, but examination in the supine position alone identified high-risk gastric contents
210 in one third of such cases.

211 Our results support former studies suggesting that extremity fractures may often entail
212 delayed gastric emptying [3,4]. These studies, based solely on contents aspirated via a gastric
213 tube are likely to overlook children with thick liquid or solid gastric contents that are not
214 amenable to suction. Delayed gastric emptying in children with acute illnesses has been also
215 demonstrated in recent US studies conducted in the pediatric emergency department [27–29]
216 and the operating room [15]. The timing of last oral intake in relation to the trauma, and total
217 fasting time before surgery, are factors often considered important in the context of
218 emergency pediatric surgery [4]. Despite this, children with prolonged fasting times and those
219 who remain *nil per os* post-trauma may also have high-risk gastric contents. In the present
220 study, the multivariable analysis found no independent association for timing of last oral
221 intake in relation to the trauma nor for prolonged fasting for up to 10 hours. It is therefore
222 impossible to draw any conclusions about the influence of the duration of fasting in this
223 context. Application of preoperative fasting guidelines for urgent and semi-urgent trauma
224 cases remains essential for all children.

225 As observed recently in adults, it is difficult to predict gastric contents in patients
226 presenting with surgical emergencies [30]. There is a variety of criteria used in clinical

227 practice to predict gastric contents following a trauma [31]. The area under the ROC curve
228 and the goodness of fit of our predictive model show that certain elements of the patient's
229 medical history and clinical features can help to predict gastric contents in children with an
230 acute extremity fracture. Our results confirmed the classic delay in gastric emptying induced
231 by opioid analgesics [7], and the influence of fracture location (proximal *versus* distal limb
232 segment), which has also been proposed in the literature [3,32]. Abdominal auscultation could
233 help to identify diminished gastrointestinal peristaltic activity but is rarely undertaken
234 preoperatively in this context [31]. The absence of bowel sounds, albeit an uncommon finding
235 after isolated limb trauma, appears to be a good predictor of high-risk gastric contents.
236 Evidence of improved gastric emptying after an overnight rest between trauma and surgery
237 suggests a potential benefit in postponing out-of-hours operative treatment of non-urgent
238 fractures. Finally, preoperative immobilization of the injured extremity, which was effective
239 in most cases in our cohort, may have a favorable impact on gastric emptying [2].

240 Our study suggests that preoperative gastric US in the supine position is almost always
241 feasible in children with an acute isolated extremity fractures. In contrast, scanning in the
242 RLD position was impossible in more than 50% of cases, notably those with a fracture of a
243 proximal limb segment and/or involving the lower extremity. This limitation of gastric US
244 before emergency surgery has been previously noted in adults [19,30]. Despite this constraint,
245 examination in the supine position alone (RLD position unattainable) found solid/thick liquid
246 or clear liquid contents in more than a third of these children, allowing a diagnosis of high-
247 risk gastric contents. There is however uncertainty about gastric contents in children for
248 whom the antrum was empty in the supine position and the RLD position was infeasible.
249 Although it is likely that the majority of them had low-risk gastric contents, high-risk gastric
250 contents cannot be excluded. The supine position alone can rule in, but not rule out, high-risk
251 gastric contents.

252 Preoperative gastric US thus provides information that could help the anesthetic
253 management in most of children with an acute isolated extremity fracture. This could help
254 avoid unwarranted rapid sequence induction in children with “empty stomach”, while
255 simultaneously allowing the detection of the group at potential risk of aspiration (those with
256 “full stomach”) [15,33]. When the gastric US shows an empty antrum in both the supine and
257 RLD positions, an inhalational induction could be used without compromising patient safety
258 and airway control without an endotracheal tube (*e.g.* supraglottic device, facemask) could be
259 envisaged. In addition, rapid-onset NMBAs can be avoided, with a concomitant reduction in
260 the overall perioperative risk of a major allergic reaction. **In our cohort, the anesthetic strategy**
261 **was not always concordant with the result of the gastric US, a finding also reported in another**
262 **recent study of preoperative gastric US before non-elective pediatric surgery [15]. This**
263 **underlines the fact that other elements (*e.g.* type and duration of the procedure and the child’s**
264 **clinical status) may also need to be considered when planning anesthesia.**

265 This study has several limitations. Firstly, because of its single-center design, this
266 study may reflect the pediatric population specific to our catchment area (mixed urban and
267 alpine), and regional and local trauma management strategies. External validation, ideally
268 with a multi-center study, would be required to further evaluate and consolidate our findings.
269 Secondly, given the limited sample size, the power of the study may be insufficient to
270 correctly identify all predictors of high-risk gastric contents by multivariable analysis. This
271 secondary analysis should thus be interpreted with caution. Future larger studies will need to
272 anticipate the substantial proportion of children for whom gastric contents remain
273 indeterminate due to the impossibility of positioning the child in the RLD position. A third
274 limitation is that a low frequency convex probe was used for gastric US in all children
275 regardless of age. A high frequency linear probe might have improved the quality of the US in
276 the younger children [34]. **As gastric aspiration after induction was not systematically**

277 performed in our cohort, the correlation between GFV estimated by US and the volume of
278 gastric fluid amenable to aspiration could not be determined. Another limitation is that, the
279 threshold of GFV above which the aspiration risk becomes significant remains a matter of
280 debate [16,24]. A GFV above 1.5 ml.kg⁻¹ is generally considered to represent a high risk of
281 pulmonary aspiration [35], whereas a GFV below 0.8 ml.kg⁻¹ is considered low risk [15], but
282 there is an area of uncertainty between 0.8 and 1.5 ml.kg⁻¹. Because we deliberately chose the
283 lower threshold of 0.8 ml.kg⁻¹ as a precautionary principle, an overestimation of high-risk
284 gastric contents is possible. A final limitation, inherent to studies extrapolating aspiration risk
285 from gastric contents, is the lack of strong evidence of a correlation between the two factors.

286 4.1. Conclusions

287 Our study confirmed that a substantial proportion of children with an acute isolated extremity
288 fracture have preoperative gastric contents comporting a high risk of pulmonary aspiration,
289 for which a number of clinical predictive factors exists. Information provided by gastric point-
290 of-care US in this population may be of great value even in children for whom the US
291 scanning is only possible in the supine position. Further studies could be useful to assess the
292 precise role of gastric US in the determination of anesthetic strategy for emergency pediatric
293 orthopedic trauma, and to facilitate development of a clinical decision-making algorithm
294 integrating bed-side US findings.

295

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301 **References**

- 302 [1] Rennie L, Court-Brown CM, Mok JYQ, Beattie TF. The epidemiology of fractures in
303 children. *Injury* 2007;38:913–22. <https://doi.org/10.1016/j.injury.2007.01.036>.
- 304 [2] Zaricznyj B, Rockwood CA, O'Donoghue DH, Ridings GR. Relationship between
305 trauma to the extremities and stomach motility. *J Trauma* 1977;17:920–30.
306 <https://doi.org/10.1097/00005373-197712000-00005>.
- 307 [3] Olsson GL, Hallén B. Pharmacological evacuation of the stomach with metoclopramide.
308 *Acta Anaesthesiol Scand* 1982;26:417–20. [https://doi.org/10.1111/j.1399-](https://doi.org/10.1111/j.1399-6576.1982.tb01791.x)
309 [6576.1982.tb01791.x](https://doi.org/10.1111/j.1399-6576.1982.tb01791.x).
- 310 [4] Bricker SR, McLuckie A, Nightingale DA. Gastric aspirates after trauma in children.
311 *Anaesthesia* 1989;44:721–4. <https://doi.org/10.1111/j.1365-2044.1989.tb09255.x>.
- 312 [5] Thompson DG, Richelson E, Malagelada JR. Perturbation of gastric emptying and
313 duodenal motility through the central nervous system. *Gastroenterology* 1982;83:1200–
314 6.
- 315 [6] Stanghellini V, Malagelada JR, Zinsmeister AR, Go VL, Kao PC. Stress-induced
316 gastroduodenal motor disturbances in humans: possible humoral mechanisms.
317 *Gastroenterology* 1983;85:83–91.
- 318 [7] Nimmo WS, Heading RC, Wilson J, Tothill P, Prescott LF. Inhibition of gastric
319 emptying and drug absorption by narcotic analgesics. *Br J Clin Pharmacol* 1975;2:509–
320 13. <https://doi.org/10.1111/j.1365-2125.1975.tb00568.x>.
- 321 [8] Gencorelli FJ, Fields RG, Litman RS. Complications during rapid sequence induction of
322 general anesthesia in children: a benchmark study. *Paediatr Anaesth* 2010;20:421–4.
323 <https://doi.org/10.1111/j.1460-9592.2010.03287.x>.
- 324 [9] Borland LM, Sereika SM, Woelfel SK, Saitz EW, Carrillo PA, Lupin JL, et al.
325 Pulmonary aspiration in pediatric patients during general anesthesia: incidence and
326 outcome. *J Clin Anesth* 1998;10:95–102. [https://doi.org/10.1016/s0952-8180\(97\)00250-](https://doi.org/10.1016/s0952-8180(97)00250-x)
327 [x](https://doi.org/10.1016/s0952-8180(97)00250-x).
- 328 [10] Walker RWM. Pulmonary aspiration in pediatric anesthetic practice in the UK: a
329 prospective survey of specialist pediatric centers over a one-year period. *Paediatr*
330 *Anaesth* 2013;23:702–11. <https://doi.org/10.1111/pan.12207>.
- 331 [11] Habre W, Disma N, Virag K, Becke K, Hansen TG, Jöhr M, et al. Incidence of severe
332 critical events in paediatric anaesthesia (APRICOT): a prospective multicentre
333 observational study in 261 hospitals in Europe. *Lancet Respir Med* 2017;5:412–25.
334 [https://doi.org/10.1016/S2213-2600\(17\)30116-9](https://doi.org/10.1016/S2213-2600(17)30116-9).
- 335 [12] Eich C, Timmermann A, Russo SG, Cremer S, Nickut A, Strack M, et al. A controlled
336 rapid-sequence induction technique for infants may reduce unsafe actions and stress.
337 *Acta Anaesthesiol Scand* 2009;53:1167–72. [https://doi.org/10.1111/j.1399-](https://doi.org/10.1111/j.1399-6576.2009.02060.x)
338 [6576.2009.02060.x](https://doi.org/10.1111/j.1399-6576.2009.02060.x).

- 339 [13] Engelhardt T. Rapid sequence induction has no use in pediatric anesthesia. *Paediatr*
340 *Anaesth* 2015;25:5–8. <https://doi.org/10.1111/pan.12544>.
- 341 [14] Perlas A, Chan VWS, Lupu CM, Mitsakakis N, Hanbidge A. Ultrasound assessment of
342 gastric content and volume. *Anesthesiology* 2009;111:82–9.
343 <https://doi.org/10.1097/ALN.0b013e3181a97250>.
- 344 [15] Gagey A-C, de Queiroz Siqueira M, Monard C, Combet S, Cogniat B, Desgranges F-P,
345 et al. The effect of pre-operative gastric ultrasound examination on the choice of general
346 anaesthetic induction technique for non-elective paediatric surgery. A prospective cohort
347 study. *Anaesthesia* 2018;73:304–12. <https://doi.org/10.1111/anae.14179>.
- 348 [16] Moake MM, Jackson BF, Presley BC. Point-of-Care Ultrasound to Assess Gastric
349 Content. *Pediatr Emerg Care* 2020;36:404–10.
350 <https://doi.org/10.1097/PEC.0000000000001939>.
- 351 [17] Benhamou D. Ultrasound assessment of gastric contents in the perioperative period: why
352 is this not part of our daily practice? *Br J Anaesth* 2015;114:545–8.
353 <https://doi.org/10.1093/bja/aeu369>.
- 354 [18] Frykholm P, Disma N, Andersson H, Beck C, Bouvet L, Cerceuil E, et al. Pre-operative
355 fasting in children. *Eur J Anaesthesiol* 2021. *in press*.
- 356 [19] Bouvet L, Desgranges F-P, Aubergy C, Boselli E, Dupont G, Allaouchiche B, et al.
357 Prevalence and factors predictive of full stomach in elective and emergency surgical
358 patients: a prospective cohort study. *Br J Anaesth* 2017;118:372–9.
359 <https://doi.org/10.1093/bja/aew462>.
- 360 [20] Bouvet L, Bellier N, Gagey-Riegel A-C, Desgranges F-P, Chassard D, De Queiroz
361 Siqueira M. Ultrasound assessment of the prevalence of increased gastric contents and
362 volume in elective pediatric patients: A prospective cohort study. *Paediatr Anaesth*
363 2018;28:906–13. <https://doi.org/10.1111/pan.13472>.
- 364 [21] Toulouse E, Lafont B, Granier S, Mcgurk G, Bazin J-E. French legal approach to patient
365 consent in clinical research. *Anaesth Crit Care Pain Med* 2020;39:883–5.
366 <https://doi.org/10.1016/j.accpm.2020.10.012>.
- 367 [22] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al.
368 The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)
369 Statement: guidelines for reporting observational studies. *Int J Surg* 2014;12:1495–9.
370 <https://doi.org/10.1016/j.ijsu.2014.07.013>.
- 371 [23] Spencer AO, Walker AM, Yeung AK, Lardner DR, Yee K, Mulvey JM, et al.
372 Ultrasound assessment of gastric volume in the fasted pediatric patient undergoing upper
373 gastrointestinal endoscopy: development of a predictive model using endoscopically
374 suctioned volumes. *Paediatr Anaesth* 2015;25:301–8. <https://doi.org/10.1111/pan.12581>.
- 375 [24] Bouvet L, Chassard D. Ultrasound assessment of gastric volume: what is the best
376 threshold? *Anesth Analg* 2013;117:1508–9.
377 <https://doi.org/10.1213/ANE.0b013e3182a9666b>.

- 378 [25] Birnie KA, Hundert AS, Lalloo C, Nguyen C, Stinson JN. Recommendations for
379 selection of self-report pain intensity measures in children and adolescents: a systematic
380 review and quality assessment of measurement properties. *Pain* 2019;160:5–18.
381 <https://doi.org/10.1097/j.pain.0000000000001377>.
- 382 [26] Crellin DJ, Harrison D, Santamaria N, Babl FE. Systematic review of the Face, Legs,
383 Activity, Cry and Consolability scale for assessing pain in infants and children: is it
384 reliable, valid, and feasible for use? *Pain* 2015;156:2132–51.
385 <https://doi.org/10.1097/j.pain.0000000000000305>.
- 386 [27] Azad AM, Al Madi HA, Abdull Wahab SF, Shokoohi H, Kang YJ, Liteplo AS. Gastric
387 ultrasonography in evaluating NPO status of pediatric patients in the emergency
388 department. *Am J Emerg Med* 2019;37:355–6.
389 <https://doi.org/10.1016/j.ajem.2018.06.013>.
- 390 [28] Leviter J, Steele DW, Constantine E, Linakis JG, Amanullah S. “Full Stomach” Despite
391 the Wait: Point-of-care Gastric Ultrasound at the Time of Procedural Sedation in the
392 Pediatric Emergency Department. *Acad Emerg Med* 2019;26:752–60.
393 <https://doi.org/10.1111/acem.13651>.
- 394 [29] Miller AF, Levy JA, Krauss BS, Gravel CA, Vieira RL, Neuman MI, et al. Does Point-
395 of-Care Gastric Ultrasound Correlate With Reported Fasting Time? *Pediatr Emerg Care*
396 2020. <https://doi.org/10.1097/PEC.0000000000001997>.
- 397 [30] Delamarre L, Srairi M, Bouvet L, Conil J-M, Fourcade O, Minville V.
398 Anaesthesiologists’ clinical judgment accuracy regarding preoperative full stomach:
399 Diagnostic study in urgent surgical adult patients. *Anaesth Crit Care Pain Med*
400 2021;40:100836. <https://doi.org/10.1016/j.accpm.2021.100836>.
- 401 [31] Hardman JG, O’Connor PJ. Predicting gastric contents following trauma: an evaluation
402 of current practice. *Eur J Anaesthesiol* 1999;16:404–9. <https://doi.org/10.1046/j.1365-2346.1999.00513.x>.
- 404 [32] Steedman DJ, Payne MR, McClure JH, Prescott LF. Gastric emptying following Colles’
405 fracture. *Arch Emerg Med* 1991;8:165–8. <https://doi.org/10.1136/emj.8.3.165>.
- 406 [33] Gagey A-C, de Queiroz Siqueira M, Desgranges F-P, Combet S, Naulin C, Chassard D,
407 et al. Ultrasound assessment of the gastric contents for the guidance of the anaesthetic
408 strategy in infants with hypertrophic pyloric stenosis: a prospective cohort study. *Br J*
409 *Anaesth* 2016;116:649–54. <https://doi.org/10.1093/bja/aew070>.
- 410 [34] Spencer AO, Walker AM. Antral sonography in the paediatric patient: can transducer
411 choice affect the view? *Br J Anaesth* 2015;114:1002–3.
412 <https://doi.org/10.1093/bja/aev122>.
- 413 [35] Cook-Sather SD, Liacouras CA, Previte JP, Markakis DA, Schreiner MS. Gastric fluid
414 measurement by blind aspiration in paediatric patients: a gastroscopic evaluation. *Can J*
415 *Anaesth* 1997;44:168–72. <https://doi.org/10.1007/BF03013006>.
- 416

417 **Figure legends**

418 Figure 1: Flow chart

419 Figure 2: Preoperative gastric US findings in children with acute extremity fracture.

420 US: ultrasound; RLD: right lateral decubitus, GFV: gastric fluid volume.

Children undergoing anaesthesia
for limb fracture
*(between November 01, 2018 and
April 30, 2021)*

N= 721

Gastric US performed upon arrival
in the operating suite

N= 110

Included in the analysis

N= 110

No available operator
Multiple trauma
Fractures > 24-hours old
Re-operation

N= 611

Parental opposition to use of the
data

N= 0

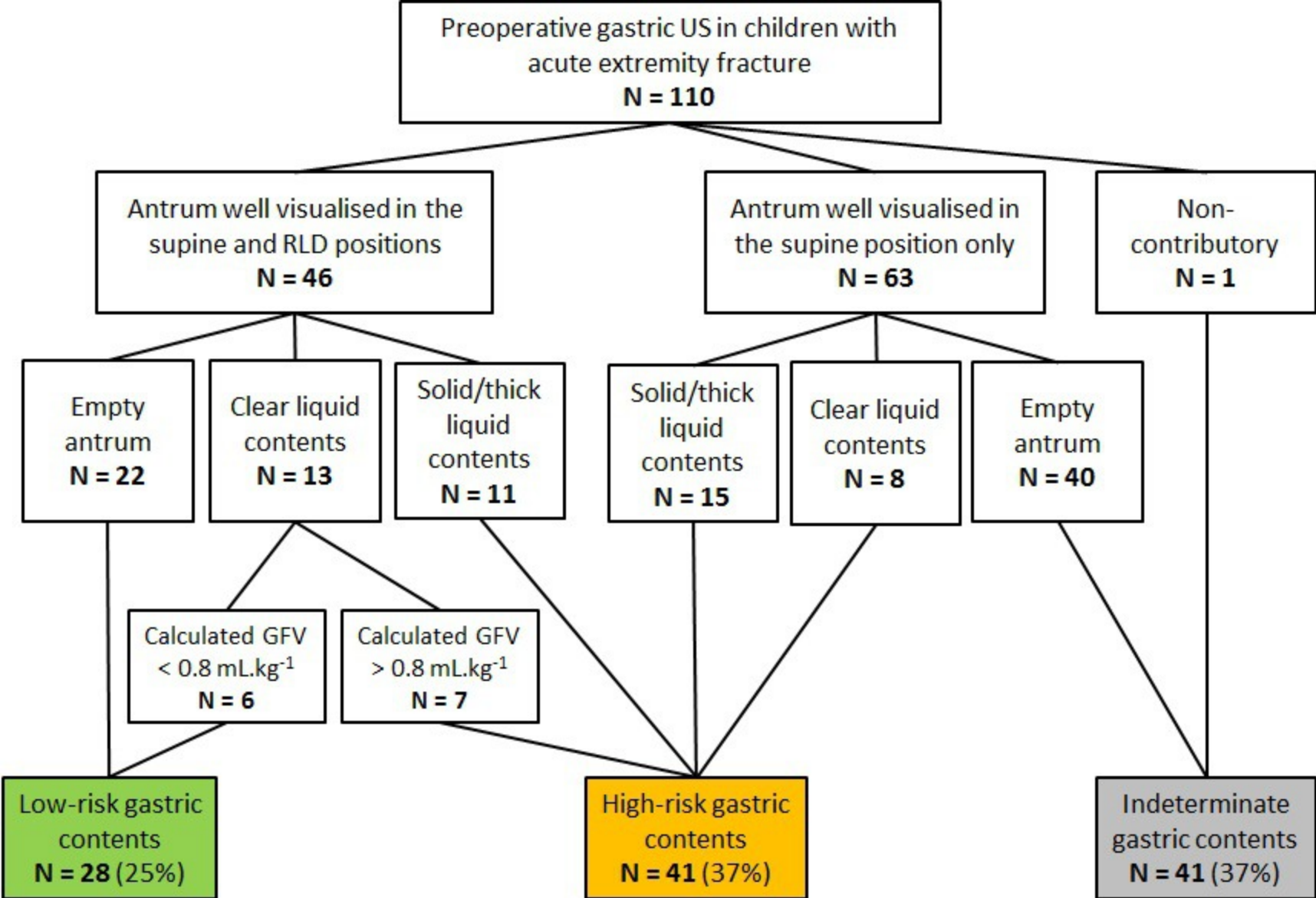


Table 1: Characteristics and clinical data of the 110 study children

	Urgent cases (<8h between trauma and operating room) <i>n</i> =55	Semi-urgent cases (8h-24h between trauma and operating room) <i>n</i> =55
Demographic data		
Male	44 (80%)	36 (65%)
Age (yrs)	10 (3)	10 (3)
Toddlers (1-3 yrs)	3 (5%)	1 (2%)
Children (4-11 yrs)	37 (67%)	33 (60%)
Adolescents (12-18 yrs)	15 (27%)	21 (38%)
Weight (kg)	32 [23-45]	30 (26-41)
Description of fracture		
Lower / upper extremity	29 (53%) / 26 (47%)	27 (49%) / 28 (51%)
Distal / proximal segment*	29 (53%) / 26 (47%)	31 (56%) / 24 (44%)
Right / left side	16 (29%) / 39 (71%)	21 (38%) / 34 (62%)
Open fracture	3 (5%)	1 (2%)
Details extracted from patient's medical history		
Time of trauma		
Interval between trauma and arrival in operating room (hrs)	6 [5-7]	12 [9-19]
Overnight rest after trauma**	0 (0%)	25 (45%)
Last solid oral intake		
Fasting time for solids before arrival in operating room (hrs)	8 [6-9]	13 [11-15]
Occurring before trauma (% / n° hours before trauma)	51 (93%) / 2 [1-3]	34 (62%) / 2 [2-3]
Occurring after trauma (% / n° hours after trauma)	4 (7%) / 1 [0-2]	21 (38%) / 7 [5-9]
Last clear fluids oral intake		
Fasting time for clear fluids before arrival in operating room (hrs)	7 [5-9]	10 [6-11]
Occurring before trauma (% / n° hours before trauma)	38 (69%) / 2 [1-3]	20 (36%) / 2 [1-3]
Occurring after trauma (% / n° hours after trauma)	17 (31%) / 1 [1-2]	35 (64%) / 6 [4-12]
Nausea / vomiting post-trauma		
None / nausea only / vomiting	44 (80%) / 6 (11%) / 5 (9%)	41 (75%) / 4 (7%) / 10 (18%)
Pain management post-trauma		
Effective immobilization (by splint or cast)	51 (93%)	53 (96%)
IV opioid analgesic (IV Morphine equivalent)		
None / 0.01-0.15 mg.kg ⁻¹ / > 0.15 mg.kg ⁻¹	8 (15%) / 32 (58%) / 13 (24%)	19 (35%) / 26 (47%) / 9 (16%)
Acetaminophen	42 (76%)	44 (81%)
NSAID	1 (2%)	13 (24%)
Equipolar mixture of oxygen and NO (Entonox®)	18 (33%)	17 (31%)
Clinical examination on admission to the operating suite		
Pain intensity (scale 0-10)	2 [0-5]	3 [1-4]
Bowel sounds presents	52 (95%)	47 (85%)

Data are number (%), mean (SD) or median [interquartile range]. NSAID: non-steroidal anti-inflammatory drugs; NO: nitrous oxide; *: Elbow fractures were considered proximal if the humerus was involved (*e.g.*, supracondylar fracture). **: trauma before 8pm and surgery after 8am the next day

Table 2: Comparison of children with acute extremity fractures, according to feasibility of RLD positioning

	Children with acute extremity fracture		<i>P value</i>
	RLD positioning feasible (<i>n</i> =46)	RLD positioning not feasible (<i>n</i> =64)	
Age (yrs)	10 (3)	10 (3)	0.60
Weight (kg)	33 [25-41]	30 [24-44]	0.98
Male (vs. female)	33 (72%)	47 (73%)	0.84
Lower extremity (vs. upper extremity)	8 (17%)	48 (75%)	< 0.0001
Proximal limb segment (vs. distal limb segment)	13 (28%)	37 (58%)	0.0021
Right side (vs. left side)	12 (26%)	25 (39%)	0.16
Pain intensity (0-10 scale)	2 [0-4]	2 [1-5]	0.28

Data are number (%), mean (SD) or median [interquartile range]. RLD: right lateral decubitus.

Table 3: Factors associated with high-risk gastric contents in children with acute isolated extremity fracture (n=110)

	Univariable analysis			Multivariable analysis		
	OR	95%CI	P-value	AOR	95%CI	P-value
Demographic data						
Male	0.9	[0.4-2.0]	0.72			
Age (+ 1 yr)*	0.9	[0.8-1.0]	0.11			
Weight (+ 10 kg)**	0.7	[0.5-1.0]	0.039			
Description of fracture						
Lower extremity	0.9	[0.4-1.9]	0.73			
Proximal limb segment†	2.3	[1.1-5.1]	0.035	2.5	[1.0-6.2]	0.040
Details extracted from patient's medical history						
Time of the trauma						
Interval between trauma and surgery < 8 hours‡	3.4	[1.5-7.6]	0.0037			
Overnight rest between trauma and surgery***	0.2	[0.0-0.6]	0.0064	0.1	[0.0-0.6]	0.0084
Last solid oral intake						
Fasting for solids before surgery < 10 hours‡	3.1	[1.4-7.2]	0.0065			
Occurring < 2 hours before trauma‡	1.9	[0.9-4.3]	0.11			
Occurring after trauma	0.6	[0.2-1.5]	0.28			
Last clear fluid oral intake						
Fasting for clear fluids before surgery < 8 hours	1.6	[0.7-3.4]	0.26			
Occurring < 2 hours before trauma‡	2.2	[0.9-5.4]	0.075			
Occurring after trauma‡	0.5	[0.2-1.1]	0.085			
Nausea / vomiting post-trauma	1.2	[0.5-2.9]	0.75			
Pain management post-trauma						
Opioid analgesic‡	3.4	[1.2-9.9]	0.024	3.9	[1.1-13]	0.030
Non-opioid analgesic	1.8	[0.6-5.0]	0.27			
Equimolar mixture of oxygen and NO	1.2	[0.5-2.6]	0.72			
Clinical examination upon admission to the operating room						
Self-reported pain ≥ 4/10	1.5	[0.7-3.3]	0.34			
Bowel sounds absent‡	3.3	[0.9-12]	0.068	8.0	[1.4-44]	0.018

OR: odds ratio; AOR: adjusted odds-ratio; CI: confidence interval; NO: nitrous oxide. *: Age and weight were positively correlated (p<0.0001). **: Trauma before 8pm and surgery after 8am the next day. ‡: included in the multivariable analyses. †: Elbow fractures were considered proximal if the humerus was involved (e.g., supracondylar fracture).

Table 4: Anesthetic strategy according to preoperative gastric contents assessed by ultrasound.

	Preoperative gastric contents in children with acute extremity fracture assessed by ultrasound (n=110)			P-value
	Low-risk gastric contents (n = 28)	High-risk gastric contents (n = 41)	Indeterminate gastric contents (n = 41)	
Airway control device set up				
Face mask / Supraglottic device	22 (79%)	4 (10%)	20 (49%)	< 0.0001
Tracheal intubation	6 (21%)	37 (90%)	21 (51%)	
Rapid sequence induction*	0 (0%)	23 (56%)	6 (15%)	< 0.0001

Data are number (%). *: facilitated by simultaneous administration of a sedative and a rapid-onset neuromuscular blocking agent.