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1 **Weight-for-height Z-score improves in half of undernourished children hospitalized in**
2 **surgical wards**

3 Short title: Nutritional status in surgical wards

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22

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24 **ABSTRACT**

25 Background: Overall, 10–15% of hospitalized children are undernourished. The present study
26 focuses on pediatric surgical wards. We assessed the impact of undernutrition upon admission
27 on the weight-for-height Z-score (Z-WFH) during hospitalization for surgery. Secondary aims
28 were to investigate the influence of associated factors and to report on the use of nutritional
29 support.

30 Methods: All children hospitalized for a surgical procedure between July 2015 and March
31 2016 were included in this monocentric, prospective study. Children were divided into two
32 groups: whether the Z-WFH upon admission was below -2 standard deviations
33 (undernourished) or not (not undernourished).

34 Results: A total of 161 of 278 eligible children were included; 27 were undernourished (17%).
35 The change in Z-WFH during hospitalization was greater in undernourished children
36 (0.31 ± 0.11 vs. -0.05 ± 0.05 , $p=0.005$). Of undernourished children, 49% recovered a Z-WFH
37 above -2 SD during hospitalization. There was no difference between undernourished children
38 and not undernourished children regarding age, length of hospital stay, pre- and postoperative
39 duration of nil per os, duration of surgical procedure, ASA score, emergency level of the
40 surgical procedure, and enteral/parenteral nutrition.

41 Conclusion: Our data suggest that the Z-WFH of undernourished children upon admission
42 improved during hospitalization.

43 **Keywords:** undernutrition; nil per os; hospital stay; nutritional support

44

45 **1. INTRODUCTION**

46 Overall, 10–15% of hospitalized children are undernourished in medical and surgical wards.

47 The French national annual surveys of pediatric hospital undernutrition, called “e-Pinut,”

48 report an almost constant rate of undernourished children of 8–12% [1].

49 A surgical procedure is a stressor that increases catabolism, which is also increased by

50 underlying disease. Moreover, it is associated with a period of fasting that may affect

51 postoperative metabolism and nutritional status [2]. There are few data on the nutritional

52 consequences of a pediatric surgical procedure [3]. Undernutrition increases the risk of

53 postoperative complications and the duration of hospitalization [4–7]. In adults, perioperative

54 management was recommended by the French Anesthesia and Resuscitation Society (SFAR)

55 and the French-speaking Society of Clinical and Metabolic Nutrition (SFNCM) with

56 guidelines updated in 2010 [8].

57

58 The primary aim of this study was to assess the change in weight-for-height Z-score (Z-WFH)

59 during hospitalization for surgical procedures of children who were undernourished or not

60 undernourished upon admission. We hypothesized that undernourished children upon

61 admission undergo a decrease in Z-WFH during hospitalization.

62 Secondary aims of the study were to investigate the influence of potential factors associated

63 with Z-WFH change and to report on the use of nutritional support.

64

65

66 **2. MATERIAL AND METHODS**

67 2.1 Study design and population

68 This prospective, exposed/non-exposed, observational study was carried out in the department

69 of visceral, urological, and pediatric plastic surgery in a university hospital in western France.

70

71 All children hospitalized for a surgical procedure were eligible for inclusion. Inclusion was
72 continued until at least 20 undernourished children with full data available had been included
73 (between July 2015 and March 2016). Children with anthropometric measures missing upon
74 admission and/or at discharge were excluded. In our institution, a resident in pediatrics is
75 specifically dedicated to nutritional status assessment in surgical wards. The resident's role
76 was, half day on work days, to perform screening and nutrition therapy of all hospitalized
77 children. This resident in pediatrics junior physician is a "go-between" and interacts with
78 surgeons, anesthetists, and pediatricians specialized in nutrition.

79

80 2.2 Clinical variables

81 Weight was measured for each child upon admission and at discharge with a weighing scale
82 ProDoc, PD200M, DETECTO® (100-g precision) (Webb City, Missouri, USA) for children
83 weighing over 12 kg and a digital baby scale (10-g precision; product number 727, SECA®,
84 Hamburg, Germany) for children under 12 kg. Length was measured using a somatometer
85 with the child lying down (0.1-cm precision; JER®, France) for children shorter than 1 m, and
86 height was measured with a wall-mounted stature meter (0.1-cm precision; SOEHNLE
87 PROFESSIONAL®, Backnang, Germany) for children over 1 m. Height was measured upon
88 admission and at discharge only in children younger than 6 months and those hospitalized for
89 longer than 20 days. Upon admission, children were divided into undernourished or non-
90 undernourished groups according to whether the Z-WFH was below -2 standard deviations
91 using French growth charts; the index was chosen according to the World Health
92 Organization guidelines [9].

93 Surgical interventions were sorted into digestive, urological, plastic or other. The surgical
94 procedures were sorted into 3 levels of emergencies whether surgical procedure was carried

95 out within the 6 hours following admission (urgent), within 6 to 24 hours after admission
96 (semi-urgent) or as elective surgery. The American Society of Anesthesiologists (ASA) score
97 was recorded for each patient using the anesthesia record (1: healthy, 2: mild systemic
98 disease, 3: severe systemic disease, 4: score 3 with permanent threat to life). A clinical global
99 assessment was performed identifying children with severe clinical presentation according to
100 the French Pediatric Society (SFP) guidelines [10]. Nutritional support was defined as enteral
101 nutrition or parenteral nutrition.

102

103 2.3 Calculated variables

104 All data were gathered from the hospital's computerized medical records. e-Pinut expert
105 software (www.epinut.fr) was used for the calculation of height and Z-WFH. Length of stay
106 (LOS) was expressed in days. Preoperative nil per os (NPO) duration (hours) was the
107 difference between the last oral feeding and the starting time of the surgical procedure.
108 Postoperative NPO was the difference between the end of surgery and the time of recovery of
109 any type of oral intake. Surgical procedure duration was the time between surgical incision
110 and closure. The amount of infused sodium during the surgical procedure was calculated from
111 medical records and expressed in mEq/kg.

112

113 2.4 Ethics

114 The Internet data and e-Pinut expert software (www.epinut.fr) were approved by the advisory
115 committee on the processing of research information in the field of health (CCTIRS) on
116 23/03/2016. The National Commission for Data Protection and Freedoms (CNIL) issued a
117 declaration of conformity, no. 2034866, on 13/02/2017. Written information was delivered to
118 parents, giving them the opportunity to decline participation in this noninterventional study.
119 The local ethics committee approved the study.

120

121 2.5 Statistical analysis

122 Statistical analysis was performed using JMP® 12.2.0 software (SAS Institute Inc., Cary,
123 North Carolina, USA). Continuous variables are expressed as mean \pm standard deviation. The
124 primary outcome for the two groups was tested using a *t* test. Univariate associations between
125 the main outcome, Z-WFH change, and some variables of interest (age, Z-WFH upon
126 admission, LOS, pre- and postoperative NPO duration, duration of the surgical procedure)
127 were tested using Spearman's correlation coefficient. The effect of qualitative variables
128 (group, type of surgery, level of emergency of the surgical procedure, ASA score,
129 enteral/parenteral nutrition implementation) on the Z-WFH was analyzed through a *t* test or
130 ANOVA for more than two categories. A multivariate logistic regression was used to test
131 continuous variables (age, duration of hospitalization, amount of sodium perfused during
132 surgery) and categorical variables (gender, presence of undernutrition) associated with
133 positive weight gain. Missing data were not considered. A value of $p < 0.05$ was considered
134 statistically significant.

135

136

137 **3 RESULTS**

138 3.1 Study population characteristics

139 A total of 161 children of 278 eligible participants were included in the analysis (Figure 1).
140 We compared the characteristics of the included children ($n=161$) with those of the excluded
141 children using the anthropometric data upon admission if they were available ($n=78$).
142 Excluded children did not differ in Z-WFH and sex ratio but they were older (8.6 ± 0.6 vs.
143 5.5 ± 0.4 years, $p < 0.0001$).

144 Surgical procedures were digestive (61%), urological (22%), plastic (12%), or other (5%).
145 Surgical procedures were performed within 6 h and 24 h, respectively, in 8% and 47% of
146 cases. Elective surgery represented 45% of surgical procedures. ASA scores were 1 (64%), 2
147 (25%), 3 (11%), and only one child had an ASA score of 4.
148 The characteristics of the children are presented in Table 1. Overall, 27 children were
149 undernourished upon admission (17%). Undernourished children did not differ from non-
150 undernourished children regarding age, LOS, chronic disease frequency, pre- and
151 postoperative NPO duration, duration of the surgical procedure, ASA score, emergency level
152 of the surgical procedure, or enteral/parenteral nutrition implementation (Table 1). We did not
153 observe any effect of the ASA score and emergency level of the surgical procedures on the
154 frequency of undernutrition.
155 The change in Z-WFH during hospitalization was greater in children who were
156 undernourished upon admission. Of the children undernourished upon admission, 13 (49%)
157 recovered a Z-WFH above -2 SD at discharge. In total, 5% of children ($n=8$) lost $\geq 5\%$ of
158 weight during hospitalization and in 4% ($n=7$) the Z-WFH decreased by 1 SD. In 2% of
159 children ($n=4$) the Z-WFH decreased below -2 SD. In all, 8% ($n=13$) had a height-for-age Z-
160 score (Z-HFA) of less than -2 SD (stunting), compatible with chronic malnutrition, among
161 which three patients had both Z-WFH and Z-HFA below -2 SD. The change in Z-WFH
162 during hospitalization was greater in children with stunting upon admission (0.38 ± 0.17 SD vs.
163 -0.02 ± 0.05 SD, $p=0.02$).

164

165 3.2 Factors affecting outcome (univariate analysis)

166 The change in Z-WFH was greater in patients who received nutritional support (0.4 ± 0.3 vs.
167 0.0 ± 0.1 , $p=0.007$), and it was negatively correlated with age ($p=0.0003$). The Z-WFH upon
168 admission and postoperative NPO duration were positively correlated with LOS (all $p<0.05$)

169 in univariate analysis. The correlations remained significant after multivariate analysis for all
170 factors, except for LOS and nutritional support. No association was observed with the type of
171 surgery, ASA score, level of emergency, preoperative NPO duration, saline infused during
172 surgical procedure, and duration of surgical procedure.

173 Children younger than 3 months stayed longer in hospital (Table 2). Children older than 2
174 years remained fasting for a longer period of time after the surgical procedure, while those
175 between 3 months and 2 years of age remained fasting for a shorter period of time before the
176 surgical procedure. No differences were observed between age groups regarding Z-WFH
177 upon admission and duration of the surgical procedure.

178

179 In total, 17 patients received nutritional support (enteral nutrition $n=3$). Age, pre- and
180 postoperative NPO duration did not differ in children receiving artificial nutrition. Surgical
181 procedure duration (113 ± 18 vs. 61 ± 4 min, $p=10^{-4}$) and LOS (35 ± 3 vs. 7 ± 5 days, $p=10^{-4}$) were
182 longer in the group of patients receiving nutritional support.

183

184

185 **4. DISCUSSION**

186 The change in Z-WFH during hospitalization was greater in children who were
187 undernourished upon admission. The Z-WFH change was negatively correlated with age, but
188 no association with other factors was found. Patients receiving nutritional support had longer
189 surgical procedure and LOS. The pre- and post-NPO periods observed were far greater than
190 recommended in guidelines.

191

192 Most studies recommend the systematic use of screening tools for nutritional status or
193 nutritional risk, i.e., predicting weight loss during hospitalization [11–13]. Weight change was

194 greater in undernourished children and those with stunting, as reported in a previous study
195 [14], but only 50% of case were above -2 SD during hospitalization. Age was the only factor
196 found to be (negatively) correlated with the change in Z-WFH. This may suggest that
197 healthcare personnel pay more attention to infants and “lean” children when no standardized
198 nutritional care procedure is set-up. In our institution, a resident in pediatrics is specifically
199 dedicated to assessing nutritional status in surgical wards. This junior physician plays the “go-
200 between” and interacts with surgeons, anesthetists, and pediatricians specialized in nutrition.
201 Therefore, extrapolation of these results to other surgical wards must be made with caution.
202 The frequency of undernutrition was 17%. Although these findings are consistent with data
203 we previously obtained from a large-scale survey, the frequency is higher than in a recent
204 study where undernutrition was present in 10% of children seen in preoperative consultation
205 for anesthesia (visceral and orthopedic surgery) [15] and in a European study, which found a
206 frequency of 13% [7]. The frequency of children who underwent a weight loss of >5% during
207 hospitalization was similar to the rate reported in the latter publication [7]. We did not find a
208 higher frequency of undernutrition in children with data on height and weight upon admission
209 not included (i.e., without discharge data), which rules out a recruitment bias. Our
210 observational study was not designed as a prevalence study. Our hospital is a reference center
211 for pediatric surgery and the only university hospital for the Loire Valley region in France
212 (total population 2.6 million in 2014). Therefore, the experience is that of a single center with
213 a strong focus on pediatric nutrition. Again, the extrapolation of these results to other centers
214 or more generally to the population of children hospitalized for visceral surgery must be made
215 with caution.

216

217 In total, 9% of the children received nutritional support, mostly parenteral nutrition. In
218 children, as well as in adults, nutritional support, i.e., enteral or parenteral nutrition, should

219 start as soon as the nutritional risk becomes apparent [16]. In children, artificial nutrition is
220 recommended if nutritional goals cannot be reached within 7 days postoperatively [17]. Some
221 authors proposed criteria for prolonged ileus and recovery in acute appendicitis that may be
222 considered as risk factors for undernutrition [18]. It is noteworthy that the duration of the
223 surgical procedure and LOS were longer in children requiring nutrition therapy. However,
224 validation of this index is necessary. Efforts are needed to improve nutritional assessment and
225 care with tools specific to surgical wards.

226

227 Although most scientific societies recommend shortening NPO periods either pre- or
228 postoperatively, the NPO periods observed were far longer than the recommendations. Solid
229 or artificial milk, breastfeeding, and clear fluids are allowed, respectively, up to 6, 4, and 2 h
230 before surgery [3,19,20] and fluid ingestion 3 h after surgical procedures [20]. Longer NPO
231 periods were reported by other authors [2,21]. It may take a long time to change practices.
232 The longer NPO periods may also contribute to weight loss after surgery, to related
233 complications, to increased LOS, and may impact on the wellbeing of the child. We found a
234 positive correlation between postoperative NPO duration and LOS. The Enhanced Recovery
235 After Surgery (ERAS) protocols were established mainly for adults [16] and need to be
236 implemented in children [21,22]; they may also help to better indicate and limit nutrition
237 support use. Failure to follow the recommendations may increase the children's discomfort
238 [2].

239

240 **5. CONCLUSION**

241 One child in two loses weight during hospitalization for surgical procedures, while 10%
242 require nutritional support. In our study, pre- and postoperative NPO duration were longer
243 than recommended. Further research is needed to (1) target and follow up children at risk of

244 undernutrition, (2) identify fast and simple items predicting weight loss in children
245 undergoing surgery in order to initiate nutritional care as soon as possible, (3) improve factors
246 that may contribute to hospital undernutrition (e.g., NPO duration, pain management, avoid
247 procedures that may impair food intake). A multidisciplinary approach gathering surgeons,
248 anesthetists, and pediatricians is instrumental in establishing nutritional assessment and care
249 procedures with the whole pediatric surgical ward.

250

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253

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257

258 CONFLICT OF INTEREST STATEMENT

259 Conflict of interest: none.

260

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322

323 **Table 1:** Patient characteristics and group comparisons

324

	All <i>n</i> =161	Not undernourished <i>n</i> =134	Undernourished <i>n</i> =27	<i>p</i>
Upon admission				
% girls	42	43	41	0.86
Age (years)	5.5±0.4	5.6±0.5	5.3±1.0	0.78
Z-WFH (admission)	-0.5±0.1	-0.1±0.1	-2.4±0.2	<10 ⁻⁴
Z-WFH change	0.01±0.05	-0.05±0.05	0.31±0.11	0.005
% ASA score over 1	36	35	45	0.68
% elective surgery	45	46	44	0.92
% severe clinical presentation	17	16	18	0.73
% chronic disease	32	37	31	0.43
During hospital stay				
Length of stay (d)	9.5±1.1	9.7±1.2	8.6±2.7	0.58
Surgical procedure duration (min) (missing: <i>n</i> =1)	66.1±4.0	67.1 ±4.4	61.2 ±9.8	0.21
Preoperative NPO duration (h)	14.1±0.8	14.1 ±0.8	14.0±1.8	0.96
Postoperative NPO duration (h)	24.9±2.2	24.1 ±2.4	29.0±5.4	0.41
Perioperative sodium	4.1±0.3	4.1±0.3	3.9±0.7	0.84

load (mEq/kg)

% Nutrition support	9	11	8	0.64
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325

326 Results are mean \pm standard deviation, comparisons between groups were made using

327 Student's *t* test or the chi-square test for categories.

328 ASA: American society of anesthesiologists, NPO: nil per os, % Nutrition support: %

329 children requiring nutritional support implementation (enteral or parenteral), Z-WFH: z-score

330 for weight-for-height using French standards.

331

332 **Table 2:** Age in subgroup comparisons

333

	All	Age<90 days	90 days ≤age< 2 years	2 years ≤age< 10 years	Age≥ 10 years	<i>p</i>
n	161	36 (22%)	35 (22%)	40 (25%)	50 (31%)	
Length of stay (days)	9.5±1.1	16.3±4.3	6.3±1.3	7.1±0.8	8.7±1.1	0.009
Z-WFH	-0.5±0.1	-0.3±0.3	-0.7±0.3	-0.7±0.2	-0.2±0.2	0.39
Surgical procedure duration (min) (missing: <i>n</i> =1)	66±4	57±8	72±7	63±6	71±10	0.55
%NS (<i>n</i>)	9 (14)	14 (5)	6 (2)	8 (3)	8 (4)	0.66
Preoperative NPO duration (h)	14±1	16±3	10±1	16±1	14±1	0.03
Postoperative NPO duration (h)	25±2	11±2	12±2	37±5	34±5	<10 ⁻⁴

334

335 Comparisons between age groups using ANOVA or chi-square test for categories.

336 NPO: nil per os, %NS: % nutritional support (children requiring enteral or parenteral

337 nutrition), Z-WFH: weight-for-height Z-score using French standards.

338 FIGURE LEGEND

339 **Figure 1:** Study flowchart

340

278 eligible children

No weight at admittance: 7 children

No height at admittance: 32 children

No weight at discharge: 78 children

161 included children

27 undernourished

134 non-undernourished