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1 Parental nutrition in emergency surgery: a multicentre cross-
2 sectional study

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10 On behalf of The Nutrition in Emergency Surgery (NEmS) collaborative (appendix one)

11
12 Daniel Ashmore and Matthew Lee made an active contribution to the conception, analysis, drafting
13 and critical review of the paper with approval of the final version submitted for publication. The
14 NEmS collaborative made an active contribution to the collection of data, drafting and critical
15 review of the paper with approval of the final version submitted for publication.

16
17 *Key words:* Emergency general surgery; nutritional assessment; parenteral nutrition; delivery of
18 nutrition; decision making.

21 Abstract

22

23 *Background*

24 Emergency general surgical patients are inherently at high risk of malnutrition. Early decision
25 making with implementation is fundamental to patient recovery. For many patients, parenteral
26 nutrition (PN) is the only feeding option available. This study assesses the timing and outcomes of
27 this decision making process.

28

29 *Methods*

30 A sample of at least 10 consecutive adult patients admitted as a general surgical emergency to eight
31 UK hospitals over one year whom had received PN. Patient demographics, basic descriptors and
32 nutritional data were captured. Process measures regarding dates decisions were made or activities
33 completed were extracted from records, as were outcome measures including PN complications. Six
34 time frames examining the process of PN delivery were analysed. Associations between categorical
35 and binary variables were investigated with chi-squared test with significance determined if p
36 <0.05 .

37

38 *Results*

39 A total of 125 patients were included. Intestinal obstruction was the most common diagnosis with
40 59% of all patients deemed high risk on nutritional assessment at admission. Median time to
41 decision for PN was five days following admission ($n = 122$, IQR 7). Patients received PN for a
42 mean of 11 days. Eighty-five percent of patients developed a complication; a phosphate abnormality
43 was the most commonly reported (54%). Only altered blood glucose levels appeared to correlate
44 with a delay in starting PN ($p < 0.01$).

45

46 *Conclusion*

47 This study shows there are delays in the decision to use PN in the acutely ill surgical patient. Once
48 initiated, the pathway is relatively short. There are high rates of electrolyte abnormalities in this
49 population.

50

51 Introduction

52

53 Emergency general surgery provides complex management for patients admitted with an acute
54 surgical pathology ⁽¹⁾. Poorer outcomes have been established in this high risk group in the UK ^(2,3)
55 and globally ^(4,5). The emergency general surgery patient population is also commonly an at-risk
56 patient group for being malnourished. There may be a variety of reasons including; poor oral intake
57 prior to admission, greater fluid disturbances, being kept nil by mouth while awaiting or recovering
58 from emergency surgery, and then proceeding to surgery which in itself has a metabolic stress
59 response exacerbating the issue ⁽⁶⁾.

60

61 It is recommended all patients admitted to hospital within the UK are assessed with a nutritional
62 screening tool for malnutrition, for example, the Malnutrition Universal Screening Tool (MUST)
63 ^(7,8). Both admission and ‘highest during admission’ MUST scores predict the need for artificial
64 nutritional support ⁽⁹⁾. Many patients with acute abdominal pathology will also have type I
65 intestinal failure, leading to a high risk of malnutrition. This means that parenteral nutrition (PN) is
66 the only option for a number of acute surgical patients who will have a prolonged period without
67 adequate oral or enteral nutrition, due to intestinal obstruction, perforation or failure ^(10,11). In the
68 UK, nutritional support for those malnourished or considered at risk of malnutrition is
69 recommended ⁽⁷⁾. Guidelines from European and American Societies for Parenteral and Enteral
70 Nutrition offer relatively less clarity and focus on the use of PN in the elective surgical patient
71 ^(12,13). Malnutrition is recognised as having significant negative effects in the elective setting ⁽¹³⁻¹⁵⁾.
72 Similar observations have been made in the emergency setting ⁽¹⁶⁾, but evidence on the efficacy of
73 interventions for the acutely unwell surgical patient is lacking.

74

75 The process to commence PN may be challenging. Vascular access must be secured ⁽¹⁷⁻¹⁹⁾ and input
76 of Nutritional Support Teams (NST) is recommended^(7,10,20-22). In addition, the patient must
77 undergo metabolic optimisation to avoid or minimise the occurrence of electrolyte abnormalities
78 which may lead to refeeding syndrome ⁽²³⁻²⁵⁾. Previous work has suggested that variations in
79 availability and access to nutrition and related services might be related to the use of it in the
80 emergency setting ⁽²⁶⁾. It has also been suggested that recognition of the risk of malnutrition does
81 not lead to the use of nutritional interventions ⁽²⁷⁾.

82

83 This study aimed to review the pathway to receiving parenteral nutrition and associated outcomes in
84 emergency general surgical patients in the UK. Specific objectives were 1) to examine the time
85 frames to initiate PN and identify potential delays for commencing PN; 2) to consider whether

86 patients assessed as high risk using a validated risk assessment tool were also considered high risk
87 of refeeding syndrome clinically; 3) to assess whether patients deemed high risk of refeeding
88 syndrome were given appropriate supplementation (thiamine/ B12); and 4) review the outcomes of
89 patients who received PN in terms of common electrolyte disturbances, and line related
90 complications.

91

92

93 Methods

94

95 This study is reported with reference to the STROBE guidelines ⁽²⁸⁾. It is a multi-centre,
96 retrospective study of consecutive patients receiving PN between January and December 2018.

97

98 *Centre selection*

99 Candidate centres were identified through participation in previous emergency surgery audit work
100 ⁽²⁹⁾. A convenience sample of 8 sites from different geographical regions of the UK was
101 purposively selected to ensure local or regional policies did not bias findings. All sites provided
102 emergency surgical services and have the capacity to provide parenteral nutrition in the emergency
103 setting.

104

105 *Case identification*

106 Adult patients aged 18 and over admitted as a general surgical emergency that had received PN
107 during their admission were identified at each centre. Eligibility was confirmed by cross referencing
108 admission records with records of the local nutrition specialist team. All general surgical
109 emergencies, as were both non-operative and operative cases eligible for inclusion. Sites were asked
110 to identify approximately 10 consecutive patients to allow comparison.

111

112 *Data extraction*

113 Records were reviewed by local collaborators to confirm eligibility. Data were collected from three
114 time points during the patient's admission; on admission; decisions relating to parenteral nutrition;
115 and outcomes following PN. Data was collated locally, and anonymised data was uploaded to a
116 central REDCap server ⁽³⁰⁾ which is housed at the University of Sheffield. The server is encrypted
117 and accessible only by username and password through an SSL connection within a browser. A
118 sample collection report form and definitions are shown in appendix two.

119

120 *Admission data*

121 Data relating to demographics (age, sex, height, weight), surgical diagnosis ('intestinal obstruction',
122 'intra-abdominal sepsis', 'intestinal perforation', 'intestinal ischaemia' and 'other intra-abdominal
123 condition'), biochemical markers (white cell count $\times 10^9/L$ (WCC) and albumin (g/L) on admission)
124 and the date of the first nutritional assessment were collected. Body Mass Index (BMI) was
125 calculated from weight (Kg)/height (m²).

126

127 *Process measures/definitions*

128 Process measures namely constituted dates decisions were made or activities completed, as defined
129 in appendix 2. These included a date for: admission; decision for PN; line requested; line inserted;
130 PN started; and PN stopped. This allowed for the time frames between two decisions to be analysed.
131 In addition, data regarding the type of line used for PN (dedicated cannula/ peripherally inserted
132 central catheter (PICC)/central venous catheter (CVC)/other) and type of PN used (standard,
133 bespoke or other), as well as whether patients were considered high risk of refeeding syndrome
134 (yes/no) and subsequently prescribed supplementary thiamine/ B12 (yes/no).

135

136 *Outcome definitions*

137 Data relating to the following binary (yes/no) variables were collected: occurrence of
138 hypophosphataemia (serum phosphate <0.8mmol/L); hypokalaemia (serum potassium
139 <3.5mmol/L); deranged liver function tests (serum aspartate aminotransferase (AST)/ alanine
140 aminotransferase (ALT) or alkaline phosphatase (ALP) or bilirubin 1.5x upper limit of normal); and
141 line sepsis (culture confirmed or clinically suspected).

142

143 *Nutritional screening tools*

144 The nutritional assessment screening tools used were the Malnutrition Universal Screening Tool
145 (MUST), which was used in seven of the eight centres, all in England, and the All Wales Adult
146 Nutritional Risk Screening Tool ‘Weight, Appetite, Ability to eat, Stress factor, Pressure
147 ulcer/wound’ (WAASP) used in Wales, had scores converted from raw scores to low-, medium- or
148 high-risk to facilitate maximum data inclusion^(8,31). An assessment by the EGS team of risk of
149 refeeding syndrome (low, medium, high) in each patient was also included. This assessment was
150 based on clinical grounds without use of an objective score.

151

152 *Ethical approvals*

153 Use of routinely collected data to improve clinical services does not require formal research ethics
154 approval in the UK, and can be approved as a service evaluation at a local level. Local approvals
155 were secured for each participating site prior to data collection.

156

157 *Statistical analysis*

158 Statistical analysis was performed with IBM SPSS Statistics version 10. The number of days
159 between two decisions (e.g. decision between admission and line request) were calculated using
160 standard formula between two dates with Microsoft Excel 2010, then analysed as continuous data,
161 and categorical data after grouping according into 0-5 days, 6-10 days, 11-15 days, and more than
162 16 days to account for the effect of outliers. The first group 0-5 days comprises the same day (day

163 0) and five days from this. These were pre-determined groups prior to analysing the data set.
164 Groups of five days were chosen to align with NICE guidance advising nutritional support for those
165 that are identified as malnourished or considered at risk of malnutrition is started within five days of
166 admission, and there are typically five working days in a standard week. Six time frames examining
167 the process of PN delivery to patients were considered to identify potential delays for commencing
168 PN.

169
170 These included the: 1) number of days between the date of admission and the date the decision for
171 PN was made; 2) number of days between date of line request and line insertion; 3) number of days
172 between line insertion and starting PN; 4) number of days between date decision was made and
173 starting PN; 5) number of days between admission and starting PN; 6) and, duration of PN.
174 Independent samples median test was used to compare process measures between sites. Only
175 patients with complete data for the variables of interest were analysed, and the number of patients
176 included in each analysis are displayed. Estimated numbers of cases per site were calculated as
177 $(365/\text{number of days to identify consecutive cases}) \times \text{number of cases submitted}$, and rounded up to
178 the nearest whole number. Associations between categorical and binary variables were investigated
179 with chi-squared test with significance determined if $p < 0.05$. Patients identified as low risk of
180 malnutrition were compared to those identified as high risk by linear regression analysis for number
181 of days between PN start and PN stopped, and admission and starting PN (with number of days as a
182 continuous variable).

183 Results

184

185 *Summary*

186 A total of 125 patients were included, slightly over half of which were male (54% male (n = 67),
187 46% female (n = 57); 1 missing data). Characteristics and admission data relating to demographics
188 is shown in table one. There were no significant differences in sex regarding age, height, weight,
189 body mass index, white cell count or albumin at admission (results not shown). Intestinal
190 obstruction was the most common diagnosis (47%, n = 59), followed by intestinal perforation (22%,
191 n = 27). The number of patients scored low, medium and high risk were 35% (n = 42), 5.6% (n = 7)
192 and 59% (n = 71), respectively. Patients typically received PN for 11 days (mean 11.4 days, median
193 9 days, n = 123, SD = 13.2, IQR = 8), with half of the patients having 'off the shelf' PN (51%, n =
194 62).

195

196 *Site characteristics*

197 All sites contributed at least fifteen patients to the study over a period of 95-296 days (mean
198 151/median 124). The estimated number of emergency surgery cases receiving PN ranged from 18-
199 58 per year (mean = 41.8/median = 47). This is summarised in table two.

200

201 *Process of PN delivery*

202 Table three and figure one summarise the various time frames in the process of PN delivery.

203 *Number of days between the date of admission and the date the decision for PN was made:*

204 Although for almost two thirds of patients the decision was made for PN within the first five days of
205 their admission (64%, n = 78), the median time to decision for PN was four days (n = 122, IQR =

206 7). *Number of days between date of line request and line insertion:* The majority of lines were

207 inserted on the same day (76%, n = 80) or the next day (91%, n = 96). All lines were inserted by
208 day 6. The median number of days from request to insertion was 0 (n = 105, IQR = 0). *Number of*

209 *days between line insertion and starting PN:* Almost all patients had PN started within three days of

210 their line insertion (92%, n = 101, median = 0, IQR = 1). *Number of days between date decision was*
211 *made and starting PN:* Almost all patients (97%, n = 118) started PN with five days of deciding it

212 was appropriate, with over half (51%, n = 62) of all patients starting PN on the same day, and the
213 majority (81%, n = 98) within 1 day of the decision being made. All patients started PN within one

214 week of the decision for PN. *Number of days between admission and starting PN:* Over half of
215 patients started PN within five days of admission (59%, n = 74). Median days from admission to

216 starting PN was 5 days (n = 125, IQR = 5). *Duration of PN:* Patients received PN for a mean period
217 of 11 days (SD = 13.2). There was no significant difference in the number of days on PN for

218 patients identified as low risk when compared to patients identified as medium ($\beta = -0.9$ (95%CI = -
219 11.6, 9.7), $p = 0.854$) and high risk ($\beta = 0.3$ (95%CI = -4.7, 5.3), $p = 0.913$). Similarly, there was no
220 significant difference in the number of days between admission and starting PN for patients
221 identified as low risk when compared to patients identified as medium ($\beta = -0.74$ (95%CI = -5.9,
222 4.5), $p = 0.780$) and high risk ($\beta = 1.1$ (95%CI = -1.4, 3.5), $p = 0.385$). One site showed significantly
223 shorter time from admission to line request, but no variation in other parameters.

224

225 Of those patients identified as high risk using a validated malnutrition score, fewer than six out of
226 ten were considered high risk of refeeding syndrome clinically (59%, $n = 42/71$). Conversely, of
227 those patients identified as low risk using a validated malnutrition score, almost half of patients
228 were considered high risk of feeding syndrome (48%, $n = 20/42$).

229

230 In patients identified as high risk of refeeding syndrome clinically, almost 80% of patients
231 subsequently received supplementary vitamin supplementation (79%, $n = 51/65$). Conversely, of
232 those patients considered low risk of refeeding syndrome clinically, one third of patients received
233 supplementary vitamin supplementation (36%, $n = 21/59$). Overall, just over half the patients
234 received supplementary vitamin supplementation regardless of their risk (58%, $n = 72/124$).

235

236 *Complications of PN*

237 PN related complications affected 83% of patients, and 46% of patient experienced two or more
238 complications. Hypophosphataemia was the most common abnormality recorded at 52%. When
239 considering the duration variables as categorical data, there was no difference identified in relation
240 to the number of days between PN started and PN stopped and hypophosphataemia, hypokalaemia
241 altered LFTs, blood sugar or 'any complication' (table four). However there was a significant
242 difference between an increased number of days prior to use of PN and hypokalaemia ($p = 0.049$).

243

244 PICC lines were the most common route of vascular access (52%, $n = 64$). CVCs were used in 44%
245 ($n = 54$) and cannulas were only used in 3.0% of patients ($n = 4$). Overall, line sepsis was present in
246 7.1% ($n = 9$) patients. There were no significant differences between line type and risk of line sepsis
247 ($n = 123$, $df = 3$, $X^2 = 4.59$, $p = 0.204$). In addition, when considering the duration variables as
248 categorical data, there were no significant differences when assessing for line sepsis in relation to
249 the number of days between admission and PN started, or in relation to the number of days between
250 PN started and PN stopped (table four).

251

252

253 Discussion

254

255 This study has evaluated the process of initiating and implementing nutritional support in
256 emergency surgical patients in a range of hospital sites (table two). It shows that the main ‘delay’ is
257 the time from admission to deciding when to start PN, whereas delays in obtaining adequate venous
258 access or starting PN are minimal.

259

260 The decision to use PN was made within five days for almost two thirds of patients, with a median
261 time for the decision of four days from admission. NICE guidance recommends nutritional support
262 for those that are identified as malnourished or considered at risk of malnutrition is started within
263 five days of admission (⁷). Obtaining adequate venous access and starting PN was much more
264 efficient, with the majority of patients (81%) having obtained suitable venous access and having
265 started PN within one day of the decision for PN. Overall, it took five days to start PN from
266 admission (median = 5 days, n = 125, SD = 6.46). Despite this, some patients still experience a
267 delay in the implementation of nutritional support. Although current practice is within guidelines,
268 this time frame does not include the time the patient may actually have not been tolerating oral diet
269 prior to presenting to the emergency surgery team. We know this patient set are high risk
270 patients(²⁷). In addition to this, almost a third of patients had PN only for 0-5 days, and two-thirds
271 only for 0-10 days. This is a relatively high proportion of patients stopping in a short period of time,
272 and although not assessed here, the appropriateness and effectiveness of this is unknown. The
273 criteria for evaluating which patients warrant PN was not investigated but would be an interesting
274 avenue.

275

276 Emergency general surgery patients can be complex, and it takes time for the diagnosis and most
277 appropriate treatment plan to unveil itself. Intestinal obstruction was the most common diagnosis in
278 approximately a third of patients, whom may have been given a ‘trial’ period conservative
279 management with the hope their obstruction settles, and only if it did not was the decision made for
280 PN (³²). If this was the case, it is not known whether PN was initiated pre- or post-operatively, or
281 exactly the nature of the intestinal obstruction. Data assessing timing of surgery was not available,
282 though this would be an area to consider in any future studies assessing the impact on nutritional
283 support in EGS patients.

284

285 Approximately 40% of patients identified as high risk using a validated malnutrition score were not
286 considered clinically high risk for refeeding syndrome. Although the majority (~80%) of patients at
287 high risk of refeeding syndrome clinically did receive supplementary vitamins to minimise their

288 risk, there is room for improvement. Nutritional risk assessments are commonly completed at
289 admission and may not be repeated frequently throughout the patient's duration of stay; they remain
290 a static measure despite the patient's circumstances changing. This study found the time between
291 admission and starting PN, as well as duration of PN was not associated with severity of risk as
292 identified using a nutritional risk assessment. This suggests that the nutritional assessment at
293 admission is not a good predictor of the need for or duration of support. Further, supplementation
294 with thiamine, vitamin B and a balanced multivitamin before and during the first ten days of
295 feeding is recommended if there is a high risk of refeeding syndrome (7,25,33). It is unclear why a
296 substantial number of patients considered clinically high risk of refeeding syndrome were not
297 prescribed supplementary vitamins. This may be difficult to untangle. It may be due to poor
298 documentation of refeeding risk or decisions (20) and/ or clinicians' perceptions of risk itself (34-37).

299

300 Finally, although no concise definition exists for refeeding syndrome, it typically features
301 electrolyte imbalance including hypophosphataemia. (38). This was seen in this study, along with
302 widespread electrolyte abnormality. Almost every patient encountered a complication (electrolyte
303 imbalance or line sepsis) at some point during their PN treatment, with hypophosphataemia being
304 the most common. The rate of hypophosphataemia was slightly more common than reported in
305 some studies [39], and much higher than the 6% reported in others (40). This may have been due to a
306 difference in diagnostic criteria, and selection of patients from general surgical wards. In contrast,
307 patients in an intensive care setting would have daily blood tests and closer monitoring, potentially
308 allowing identification of early changes, and early mitigation of such disturbances (20). Further, this
309 study did not account for other risk factors such as alcohol abuse, diabetic ketoacidosis, or sepsis,
310 which are known to result in low phosphate and other electrolyte abnormalities (41,42). No difference
311 was found between electrolyte abnormality and delay to starting PN or duration of PN, except
312 hypokalaemia and delay to starting PN. These might also be associated with the underlying surgical
313 pathology. Although not assessed in this study, other studies have also shown there to be no
314 difference in nutritional status and electrolyte abnormalities, or diagnosis and electrolyte
315 abnormalities (43). The associated morbidity and mortality, and length of stay due to electrolyte
316 abnormalities, were not assessed but may be worthwhile investigating.

317

318 The main limitation of this study was the proportion of patients with incomplete data. Only 87 of
319 125 patients had complete data for all variables, however data analysis was only performed on
320 variables with complete data sets. Date of line insertion was the most common variable with
321 missing data points. Further, we did not collect data regarding: how the nutritional screening tool
322 was completed and who performed it; whether the score was calculated correctly; whether patients

323 were reassessed at any point during their admission; whether the score was a contributory factor to
324 the decision for PN; whether the hospital has a NST in situ; and the impact of surgery on the
325 process of PN delivery. Although two nutritional screening tools were used in this study, scores
326 were converted into low-, medium- and high-risk categories for maximum patient inclusion in this
327 study.

328

329 However, this study benefits from a broad selection of hospitals within the UK with wide eligibility
330 criteria. It focuses on simple outcome measures with clear definitions, and uniquely, at the
331 processes of an emergency surgical admission throughout the patient's journey from admission to a
332 decision for PN and initiation of PN. This provides a useful dataset to begin further investigation
333 into the clinical problem within this cohort.

334

335 Clearly further study is required to investigate the reasons for delays such as those seen here, as
336 well as the high rate of complications regarding PN. The impact of nutritional support teams or
337 nutritional support training amongst surgical teams was beyond the scope of this study, but may
338 warrant further research. Other avenues of research might include tools to provide better
339 prognostication on the need for nutritional support in the acutely ill surgical patient. This data
340 reflects a subset of the surgical population, but might indicate the need for more thorough
341 nutritional screening of patients. This may include early assessment of electrolytes as derangement
342 was prevalent here. Clinicians may also wish to consider local policies to speed up decision making
343 on need for parenteral nutrition.

344

345 Conclusion

346

347 The process of initiating and implementing nutritional support in emergency surgical patients
348 requires improvement. Sequelae of use of PN are common in this setting.

349

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351

352 The authors have no conflicts of interest to declare, and no funding was obtained for the study.

353

354 Transparency Declaration

355 The lead author affirms that this manuscript is an honest, accurate, and transparent account of the
356 study being reported. The reporting of this work is compliant with STROBE guidelines. The lead

357 author affirms that no important aspects of the study have been omitted and that any discrepancies
358 from the study as planned have been explained.
359

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361

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- 461

Variable	Median (range, SD)	Total (n)	Missing cases (n)
Age (years)	67.0 (18-90, 15.9)	125	0
Height (m)	1.7 (1.40-1.94, 0.1)	119	6
Weight (Kg)	70.0 (44.0-140.0, 20.2)	121	4
Body Mass Index (Kg/m ²)	24.5 (16.4-61.2, 6.9)	119	6
WCC at admission (10 ⁹ /L)	11.6 (1.4-33.6, 6.0)	124	1
Albumin at admission (g/L)	34.0 (11.0-76.0, 9.1)	124	1
Diagnosis	Frequency % (n)	Total (n)	Missing cases (n)
Intestinal obstruction	47.2 (59)	125	0
Intra-abdominal sepsis	12.8 (16)		
Intestinal perforation	21.6 (27)		
Intestinal ischaemia	7.2 (9)		
Other intra-abdominal condition	11.2 (14)		

462 Table one: Admission data. n, number of patients; SD, standard deviation.

463

Site	Number of patients	Percentage total	Days between admission of first and last case	Estimated no of cases per year
1	15	11.9	157	35
2	15	11.9	113	49
3	15	11.9	296	18
4	19	15.1	103	53
5	15	11.9	119	46
6	17	13.5	129	48
7	15	11.9	196	28
8	15	11.9	95	58
	126	100	Mean 151	Mean 41.8

465 Table two: Number of patients contributed per site with number of days between first and last
466 admission at each site. 126 patients were included; a mean of 151 days between admission of first
467 and last case.

Outcome	0-5 days	6-10 days	11-15 days	≥16 days	Mean (days)	Median (days)	Range (days)	SD	IQR (days)
Admission- decision for PN % (n)	63.9 (78)	20.5 (25)	10.7 (13)	4.9 (6)	5.7	4	0-35	6.1	7
Line request- Line insertion % (n)	99 (104)	1.0 (1)	0 (0)	0 (0)	0.4	0	0-6	0.9	0
Line insertion- starting PN % (n)	93.6 (103)	3.6 (4)	0.9 (1)	1.8 (2)	1.3	0	0-32	3.5	1
Decision for PN- PN started % (n)	97.5 (118)	2.5 (3)	0 (0)	0 (0)	0.9	0	0-7	1.3	1
Admission-PN started % (n)	59.2 (74)	24.0 (30)	10.4 (13)	6.4 (8)	6.6	5	0-36	6.5	5
PN started-PN stopped % (n)	30.9 (38)	36.6 (45)	17.1 (21)	15.4 (19)	11.4	9	1-92	13.2	8

470 Table three: Process measure data of six time frames. Data indicates the percentage (n) of patients
471 within each time frame. The number of days between two decisions were grouped into 0-5 days, 6-
472 10 days, 11-15 days, and more than 16 days. n, number of patients; SD, standard deviation; IQR,
473 interquartile range.

474

475

Outcome	0-5 days (n=74)	6-10 days (n=30)	11-15 days (n=13)	16+ days (n=8)	Overall (n=126)	p value
Hypophosphataemia	42 (57%)	13 (43%)	9 (69%)	2 (25%)	66 (52%)	0.223
Hypokalaemia	19 (26%)	10 (33%)	7 (54%)	0 (0%)	36 (29%)	0.049
Altered Liver function tests	26 (35%)	12 (40%)	6 (46%)	2 (25%)	46 (37%)	0.742
Altered blood sugar	27 (37%)	12 (40%)	9 (69%)	5 (63%)	53 (42%)	0.064
Line sepsis	6 (8%)	0 (0%)	1 (8%)	2 (25%)	9 (7%)	0.108
Any complication	60 (81%)	25 (83%)	13 (100%)	7 (88%)	105 (83%)	0.413

477 Table four: Outcome data for electrolyte abnormality and line sepsis in relation to number of days
478 between admission and PN started. Time frames were grouped into 0-5 days, 6-10 days, 11-15 days,
479 and more than 16 days 'Any complication' is a composite variable for any complication in
480 phosphate/ potassium/ liver function test/ blood sugar abnormality/ line sepsis. Percentages have
481 been rounded to nearest integer. P-value calculated using chi squared test (only summary data
482 shown).

483 Figure one: Process measure data displayed as histograms for six time frames. A = Days between
484 admission date and decision for PN. B = Days between line request and insertion date. C = Days
485 between line insertion and PN start date. D = Days between decision for PN and starting PN. E =
486 Days between admission date and PN start date. F = Duration of PN. PN, parenteral nutrition.
487