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ARTICLE

Early economic benefits of perioperative nasojejunal tube feeding in non-critical care adult surgical patients with gastric feed intolerance

Galya Chinnery[a], Anna-Lena du Toit[b], Chanel Robinson[c], Ilhaam Kippie[d], Eduard Jonas[e] and Matthias Scriba[f]

[a]*Department of Surgical Gastroenterology, University of Cape Town, Groote Schuur Hospital, Cape Town, South Africa*
[b]*Dietetics, Groote Schuur Hospital, Cape Town, South Africa*
[c]*Department of Surgery, Mitchell's Plain District Hospital, Cape Town, South Africa*
[d]*Department of Surgery, Khayelitsha District Hospital, Cape Town, South Africa*
[e]*Department of Surgery, University of Cape Town, Groote Schuur Hospital, Cape Town, South Africa*
[f]*Department of Surgical Gastroenterology, University of Cape Town Groote Schuur Hospital, Cape Town, South Africa*
Correspondence: galya.chinnery@uct.ac.za

Background: Fluoroscopy-guided endoscopic placement of nasojejunal tubes (NJT) for perioperative short- or medium-term enteral nutrition (EN) is potentially required for anatomical gastric feed intolerance.
Methods: Indication for NJT and successful insertion rates was determined. NJT insertion costs were calculated and compared with central venous catheter (CVC) insertion. Duration of NJT patency in non-critical care surgical patients was determined in days in a local cohort. EN costs were calculated over a hypothetical 28-day period factoring in expected NJT replacements due to blockage and compared with parenteral nutrition (PN) via CVC, which included routine CVC changes every 10 days. Public and private sectors were compared.
Results: One hundred and two (93.6%) NJTs were placed successfully, with gastric outlet obstruction the most frequent indication (40.4%) with a median 10 days' (range 1–68 days, IQR 6–16.75 days) usage. Irrevocable blockage occurred in 33 tubes after a median 9 days (range 3–34 days; IQR 4.75–16 days). Calculated EN costs over 28 days, including NJT replacement every 9 days, reached US$1 676.12 and PN costs with CVC replacement every 10 days, US$3 461.35 ($p < 0.001$) in the public sector. In the private sector PN costs at 28 days were significantly higher ($p < 0.001$) at US$5 261.14 compared with EN US$3 780.71. The cost benefit of EN over PN is seen after three days in the public, and four days in the private sector.
Conclusion: Exponential cost saving occurs with EN via NJT over time, even when factoring in the likelihood of NJT replacements.

Keywords: economic benefits, enteral nutrition, medium-term feeding, nasojejunal tubes

Introduction

Patients with gastric feed intolerance but with a functional and accessible distal gastrointestinal tract may benefit from enteral feeding via a nasojejunal tube (NJT). The physiological advantages of enteral feeding versus parenteral nutrition (PN) are well documented. While enteral nutrition (EN) in a critical care setting does not necessarily translate into decreased mortality, an outcome benefit has been described with the use of EN in the perioperative management of elective surgical patients, in particular in patients with gastrointestinal malignancies.[1] In addition, the cost-effectiveness of EN over PN in critical care units has been demonstrated.[2,3] This is of importance in all healthcare systems, but in particular in resource-constrained health systems often seen in low- and middle-income countries (LMIC).

In critical care patients, endoscopic bedside or fluoroscopy-guided placement of NJTs is usually successful. If the tip of the tube is advanced to the duodenum, most weighted tubes will pass into the jejunum within 24 h aided by peristalsis. In non-critical care surgical patients, indications for NJT feeding vary, with placement for perioperative short- to medium-term feeding due to obstructive or anatomical considerations that necessitate delivery of feeds beyond the ligament of Treitz being the most common. In this setting the NJT will require endoscopic placement under fluoroscopic guidance. The initial cost for the consumables and insertion of an endoscopically placed NJT exceeds the cost of a central venous catheter (CVC). Conversely, the daily costs of PN exceed that of EN. A limitation of NJTs is their propensity to become blocked, often requiring earlier than intended removal or replacement. Knowing the average lifespan of placed NJTs could be used to determine when patency duration vindicates the insertion costs. This information can be used to determine at which time point EN via an endoscopically and fluoroscopically placed NJT becomes more cost-effective than PN.

The aim of this paper was to audit our experiences with NJT usage in non-critical care patients with gastric feed intolerance, and to perform a cost comparison between PN via CVC and EN via NJT in the public and private healthcare sectors in South Africa.

Methods

Patient population

Patients eligible for inclusion into the study were identified from a prospectively maintained registry of all endoscopy procedures performed in the Upper Gastrointestinal Surgery service at Groote Schuur Hospital (registry approved by the University of Cape Town Human Research Ethics Committee, reference number 031/2015). Non-critical care surgical patients with gastric feed intolerance due to obstructive, functional or anatomical factors which necessitated delivery of perioperative feeds beyond the ligament of Treitz that had NJTs placed endoscopically between 1 March 2018 and 30 April 2020 were eligible for inclusion in the study. Surgically placed NJTs, percutaneous endoscopic jejunostomy tubes and weighted NJTs placed radiologically were excluded.

Nasojejunal tube placement technique

With patients in a left lateral position, an upper endoscopy with a standard gastroscope is performed with pharyngeal xylocaine spray under intravenous conscious sedation. With fluoroscopic and simultaneous endoscopic imaging, a standard hydrophilic soft-tipped 0.035″ guidewire is advanced beyond the obstruction or pathology into the proximal jejunum. Using a push–pull technique the gastroscope is then retracted, leaving behind the guidewire in position. The proximal guidewire is then repositioned through the nostril, while maintaining its distal enteral position, using a nasal transfer tube. A well-lubricated 10 Fr feeding tube is then fed transnasally over the guidewire under fluoroscopic guidance into the proximal jejunum. Finally, contrast is injected via the NJT to confirm correct intraluminal jejunal positioning. If there is no obstruction, the guidewire may be placed under direct endoscopic vision only, with correct distal tube placement confirmed by plain abdominal X-ray after placement (Figure 1). Successful placement is therefore defined as advancement of the feeding tube tip beyond the ligament of Treitz. If there is a high risk of intentional or accidental NJT dislodgment, an additional nasal halter is placed to secure the tube. The NJTs are routinely flushed with 20 ml of tap water at 4-hour intervals and with every change of feed to prevent blockage due to sedimentation. Any NJT blockages occurring in the ward are addressed in a stepwise approach. First, the tube is injected with warm water using a 3 ml syringe (to improve pressure of delivery) to flush out any obstructing contents. If unsuccessful, a guidewire is passed through the tube to assist in dislodging any obstruction before a solution of activated pancreatic enzymes is flushed down the tube (10 000 units pancreatin retrieved from an enteral capsule, dissolved in 30 ml water containing 1 g of sodium bicarbonate and which has been allowed to stand for 15 min before use). This enzymatic action is usually enough to dissolve most feed-related blockages.

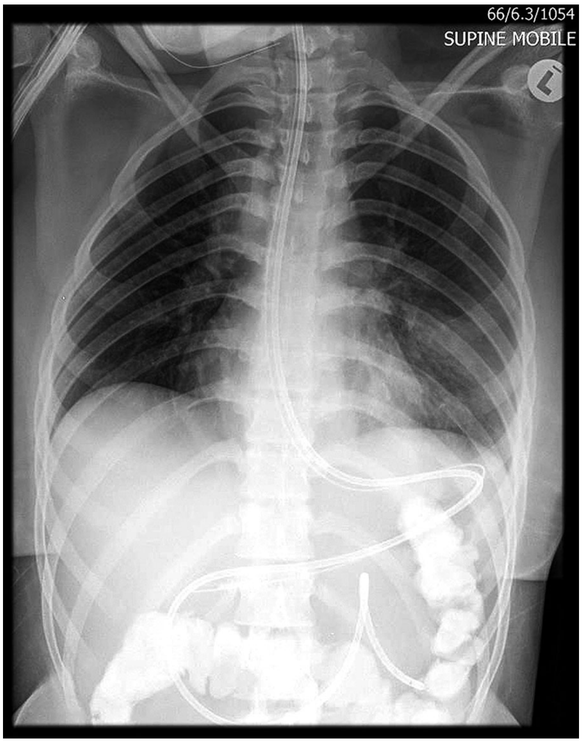

Figure 1: Plain abdominal X-ray post endoscopic placement of a nasojejunal tube confirming placement into the proximal jejunum (image includes a nasogastric tube and colonic contrast).

Assessment of outcomes

Patient demographics, indication for NJT placement, technical success of placement, days of tube patency and any attempts at unblocking for each individual blocked tube were noted. The average duration in days of usage of each tube was measured to the time point of either irrevocable blockage or when supplementary nutrition was no longer required, whichever occurred first. The time points at which EN became more cost-effective than PN were noted as endpoints (duration of tube usage required to justify the initial higher insertion costs).

Cost analysis

Cost analysis was performed as a basic comparison between EN and PN. Effectiveness of the outcomes (including adverse effects, length of hospital stay, survival, etc.) of either were not assessed or compared and as such a true cost-effectiveness analysis (CEA) was not performed in this study. Health system, fixed provider costs (including staff salaries, hospital admission costs) and patient costs (direct and indirect) were assumed to be equal in both groups and as such were not included in the cost analysis.

Costs incurred for EN and PN were calculated in South African Rand (ZAR) and converted into US dollars (US$) using the exchange rate on August 31 2021 (US$1 = ZAR14.5672). Costs of NJT or CVC insertion were calculated adding the procedural placement cost and cost of consumables. The total cost of EN and PN for a hypothetical 28-day period were calculated adding the initial placement cost, the daily cost of nutrition administration and replacements of NJTs (based on the average patency duration seen in the NJTs that did become blocked) and scheduled CVC replacements every 10 days as per local protocol.

Daily nutrition costs were calculated, aiming for full energy requirements (25–30 kCal/kg total energy, 1.2–1.5 g/kg protein/day) for an average patient of 70 kg. Daily staff time and consumables for maintenance were not included as these are equal in both groups. The time points at which EN became more cost-effective than PN were noted as endpoints (duration of tube usage required to justify the initial higher insertion costs).

Statistical analysis

Microsoft Excel (Microsoft Corp, Redmond, WA, USA) and Stata (Version 13.1; Stata Corp, College Station, Texas USA) were used for statistical analysis. Non-parametric variables were reported as median and range and/or interquartile range and parametric data as mean and standard deviation. Group comparison between the EN and PN groups for categorical data was described using a chi-square test and Fisher's exact test for expected frequencies of < 5. Student's t-test was used for parametric numerical data comparison. A p-value of < 0.05 was regarded as significant. This study was approved by the University of Cape Town Human Research Committee (reference number 658/2020).

Table 1: Indication for endoscopic nasojejunal tube insertion

Indication for nasojejunal tube placement	Number of NJTs[a]
Gastric outlet obstruction	44 (40.4%)
-Malignant	20
-Benign PUD[b]	21
-Corrosive ingestion with antral stricture	3
Anastomotic leak	15 (13.8%)
-Oesophagojejunal	10
-Gastroduodenal	3
-Duodenal	2
Penetrating trauma	13 (11.9%)
-Gastric fistula	3
-Duodenal fistula	8
-Proximal jejunal fistula	2
Severe acute pancreatitis	13 (11.9%)
Acute corrosive ingestion	10 (9.2%)
SMA[c] syndrome	5 (4.6%)
Perforated PUD[b] with fistula	4 (3.7%)
Gastroparesis	2 (1.8%)
Other	3 (2.6%)
Successful placement	102 (93.6%)
Failed placement	7 (6.4%)
Total number of placement attempts	109

[a]NJT: nasojejunal tube.
[b]PUD: peptic ulcer disease.
[c]SMA superior mesenteric artery.

Results

A total of 74 patients were included; 39 (52.7%) were male and 35 (47.3%) were female. The mean patient age was 47 years (range 18–75 years). Indications for NJT placement included preoperative nutritional optimization in patients with gastric outlet obstruction (GOO) (44.4%), anastomotic leaks (13.8%), upper gastrointestinal fistulae following surgery for penetrating trauma (11.9%) and severe acute pancreatitis (11.9%) (Table 1). Of a total of 109 attempts at NJT placement, technical success was achieved in 102 (93.6%). A total of 78 (71.6%) were placed using endoscopy and fluoroscopy, while 31 (28.4%) were placed with endoscopy only. The addition of fluoroscopy significantly improved successful placement beyond the ligament of Treitz, with initial success using fluoroscopy being achieved in 76 of 78 attempted placements (97.4%), compared with 26 of 31 placements (83.9%) using endoscopy only ($p = 0.0191$). Failure to achieve technical success was most often due to the inability to pass a guidewire across high-grade strictures or beyond large distal duodenal fistulae into the distal normal jejunum. Patients with failed tube placement received PN.

For the 102 successfully placed NJTs, the mean duration of tube usage for EN delivery prior to removal was a median 10 days (range 1–68 days, IQR 6–16.75 days). The reasons for removal of the NJTs are listed in Table 2. Fifty-five patients with NJTs did not have any tube-related complications with a median tube duration usage of 12 days (range 1–68 days; IQR 8–20 days). Of these, 51 tubes were eventually removed due to redundancy and 4 tubes remained patent at the time of death. Of the 102 successfully placed NJTs a total of 33 tube blockage events occurred in 28 (27.5%) tubes (5 tubes became blocked on two separate occasions each). In 29 of the 33 tube blockage events, 16 (55.2%) were successfully unblocked. Of the irrevocably blocked tubes that required replacement, their duration of patency prior to replacement was a median 9 days (range 3–34 days; IQR 4.75–16 days).

Table 2: Nasojejunal tube removals

Reason for NJT[a] removal	Number
Redundancy	51
Accidental removal	17
NJT[a] blockage necessitating removal	16
Routine replacement during planned interventional endoscopy	12
Death with NJT[a] in situ	4
Late malposition requiring removal after initial correct positioning	2
Total	102

[a]NJT: nasojejunal tube.

In 34 of the 102 NJTs, crushed/dissolved medications were given via the tube, but, compared with those where feeds or fluids only were given, the rate of blockage was not statistically different (26.5% for crushed/dissolved medications vs. 29.7% for feeds/fluids only, $p = 0.875$).

Costs incurred

The cost of placing an NJT by endoscopy with fluoroscopic guidance (US$ 329.50) is more than double that of CVC insertion (US$ 133.65) in the public sector (Table 3). This difference was even more pronounced in private practice, at US$ 653.98 compared with US$ 218.66 respectively.

The calculated cost benefits for both short-term (14 days) and medium-term (28 days) feeding favour EN via NJT in both private and public sectors (Figure 2). The total cost in the public sector for a 28-day period of EN via NJT, with a scheduled NJT replacement included every 9 days (as per patency duration of irrevocably blocked tubes), was US$1 676.12, compared with US$3 461.35 for PN via a CVC with a scheduled CVC replacement every 10 days ($p \leq 0.001$). In private practice the costs for medium-term EN via NJT were US$3 780.71 compared with US$5 261.14 for PN via CVC ($p \leq 0.001$) (Table 3).

The cumulative cost over time after which PN overtakes the initial higher insertion costs of endoscopic NJTs occurs on the third day of nutrition administration in the public sector and on the fourth day in the private sector (Figure 2). In public practice the difference in cost between EN via NJT and PN at 28 days was US$2 370.84 and in the private sector US$2 788.33.

Discussion

While cost effectiveness of the EN route has been well documented in critical care it is less well reported/researched in non-critical care settings.[1,4] The results of this study in non-critical care patients shows that in our clinical setting NJTs can be inserted successfully in 93.6% of attempted placements and tubes remain patent for a median of 9 days. Although the initial costs for placement of an NJT were significantly higher than CVCs in both the public and private sectors, the total cost for both a 14- and 28-day period of EN was significantly lower than PN in both sectors. Calculations of the cumulative total cost over time indicates that EN becomes more cost-effective even in the very short term: after three days in the public sector and on day four in the private sector.

Table 3: Costs of nasojejunal tube and central venous catheter placement

Factor	Public sector	Private sector
NJT[a] insertion costs (in US$):		
10Fr 240 cm NJT[a] set for endoscopic placement	155.20	148.34
Gastroscopy plus NJT[a] insertion, hospital charge	139.08	294.20
Gastroscopy plus NJT[a] insertion, specialist fee	30.14	190.84
Screening (fixed 30 min fee)	5.08	20.60
Total NJT[a] insertion cost	329.50	653.98
Cost of 1.5 l high protein semi-elemental feed per day	12.79	41.60
Total cost of 14 days' EN[b] (including initial insertion cost plus reinsertion day 9)	838.06	1890,35
Total cost of 28 days' EN[b] (including initial insertion cost plus reinsertions every 9 days)	1676,12	3780,71
CVC[c] insertion costs (in US$)		
Double lumen 7Fr 20 cm CVC[c] set	41.19	42.36
Insertion fee by anaesthetist under US[d] guidance	79.97	140.60
Abdominal X-ray (single image)	12.49	35.70
Total CVC[c] insertion cost	133.65	218.66
Cost of parenteral nutrition per day	109.30	164.47
Total cost for 14 days' PN[e] (including initial insertion costs plus replacement CVC[c] day 10)	1797,50	2739,90
Total cost for 28 days' PN[e] (including initial insertion costs plus replacement CVC[c] every 10 days)	3461,35	5261,14

Costs in US$ (valid August 2021 with US$1 = ZAR14.5672).
[a]NJT: nasojejunal tube.
[b]EN: enteral nutrition.
[c]CVC: central venous catheter.
[d]US: ultrasound.
[e]PN: parenteral nutrition.

As the global burden of disease increases, specifically cancer-related incidence and death, disproportionally so in low- and middle-income countries,[5] financial constraints are becoming more appreciable clinically with consideration of the economic implications of medical treatment now essential. In South Africa, as in many other LMIC counties, private and public healthcare systems exist in parallel, with 84% of the population dependent on public services.[6] The smaller insured proportion of patients are, however, using more than double their population share of the total benefits from healthcare services in South Africa.[6] Furthermore, as private sector costs continue to increase, the number of insured is decreasing. Minimising unnecessary expenditure in both systems is therefore paramount when weighing up service need, sustainability, availability and affordability.

It is both intuitive and well reported that perioperative nutritional optimization in gastrointestinal malignancies improves surgical and oncological outcomes, decreases postoperative morbidity and hospital length of stay and resultant costs.[7] Malnutrition rates of over 21% have been reported in the general surgical population, increasing to over 40% in patients with upper gastrointestinal malignancies presenting for elective curative treatment.[8–10] In high-income countries, most patients with any obstructive malignancy will present with significant malnutrition.[11,12] In our setting, patients with malignancies often present later and with more advanced disease, which further compounds the problem of malnutrition.

While much is written on early postoperative enteral feeding, specifically in obstructive gastric malignancies, there are few reports on the physiological benefits of preoperative enteral feeding prior to surgery.[13,14] Patients assessed as being at mild risk of malnutrition are recommended short-term (7–10 days) nutritional support prior to their surgery, while severe malnutrition requires more intensive perioperative nutritional intervention.[15,16] In malignant or benign GOO it is our standard approach to offer two weeks of EN preoperatively via NJT.

There are various techniques employed to place nasojejunal tubes in specific situations.[17] However, when there is an obstructive or specific pathology that needs to be traversed, in our opinion feeding a tube over an endoscopically placed guidewire using simultaneous fluoroscopy is the most successful in achieving the desired tube position. While Qin et al. reported a 100%

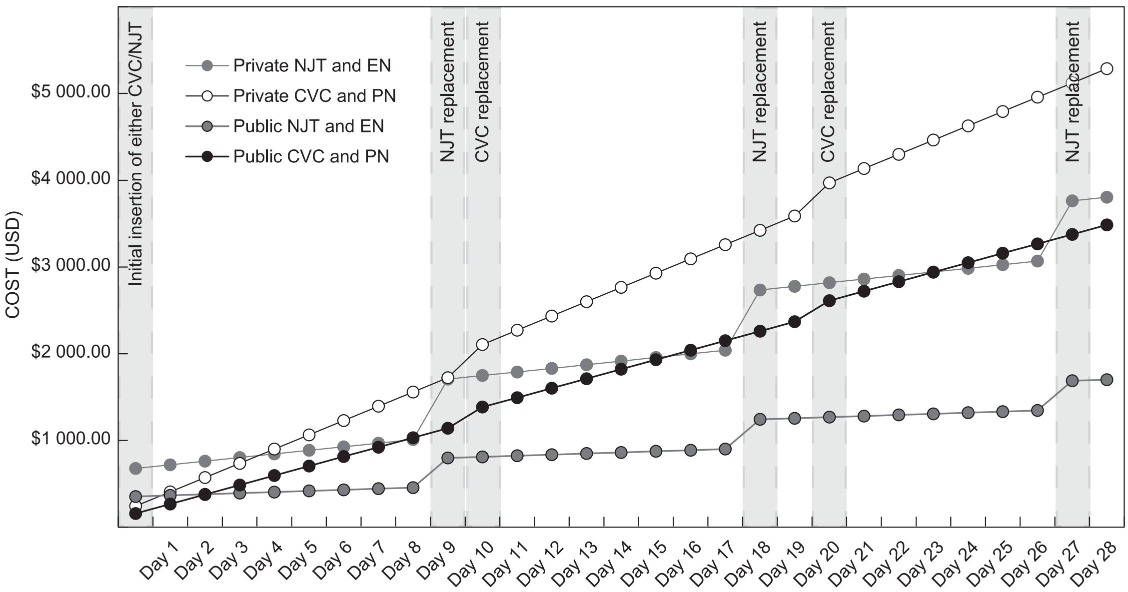

Figure 2: Cumulative costs of enteral and parenteral nutrition over a 28-day period in public and private healthcare facilities. Costs in US$ (valid August 2021 with US$1 = ZAR14.5672).

success rate with their guidewire technique, their patient cohort consisted of only non-obstructed patients.[17] Success rates of placing an NJT into or beyond the fourth part of the duodenum are lower when only the endoscopic technique is used (89.4%).[18] For comparison, patients with malignant GOO had a 91.18% success rate of a successfully placed tube beyond the obstruction using an endoscopic technique where the tube passage through an area of obstruction is facilitated by using grasping forceps through a gastroscope.[14] Our technical success rate of over 90% for placing NJTs over a guidewire using endoscopy and fluoroscopy compares favourably, with almost two-thirds of our NJTs required for anatomical obstacles.

A limitation of this study is that only insertion costs and subsequent daily nutrition costs were considered. Ensuing daily costs of ward staff and consumables in maintaining these alternative routes of nutritional access were not included. In addition, this study has not considered patient-specific pathology and subsequent outcomes, having focused on cost with an aim of justifying the initial high endoscopic NJT insertion costs.

In conclusion, it is our opinion that patients with an accessible and functional distal gastrointestinal tract requiring nutritional support for gastric feed intolerance should preferentially receive enteral feeding where the expertise for endoscopic tube placement is available. The economic benefits, even in the short term, are evident within a few days despite the higher initial outlay. Exponential cost saving occurs as time progresses, even when factoring in the likelihood of tube replacements.

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ORCID

Matthias Scriba http://orcid.org/0000-0001-8903-0510

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