



# Transanastomotic tubes reduce the cost of nutritional support in neonates with congenital duodenal obstruction

Rachel Harwood<sup>1,2</sup> · Fraser Horwood<sup>1</sup> · Violeta Tafilaj<sup>3</sup> · Ross J. Craigie<sup>1</sup>

Accepted: 1 November 2018 / Published online: 11 November 2018  
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

## Abstract

**Purpose** To determine the impact of intra-operative Trans-anastomotic Tube (TAT) placement on the cost of post-operative nutrition in infants with congenital duodenal obstruction (CDO).

**Methods** A retrospective analysis of patients undergoing corrective surgery for CDO, with birth-weight over 1.5 kg over a 10-year period. Data are presented as median (inter-quartile range) and analysed with Mann–Whitney *U* test and Fisher’s exact test as appropriate.

**Results** 59 patients were included. There was no difference between TAT and non-TAT groups for baseline characteristics, age at operation and abnormality. In the TAT group there was a significant reduction in the duration of post-operative parenteral nutrition (PN) [6 (0–11) vs 12 (8–19) days,  $p=0.006$ ], the cost of PN [£750 (0–1375) vs £1500 (1000–2375),  $p=0.006$ ] and the total cost of nutrition [£765.26 (38.36–1404) vs £1387.52 (1008.23–2363.08),  $p=0.015$ ], thereby demonstrating a median cost saving of £622.26 per patient. 14% experienced TAT displacement but no other TAT complications were encountered.

**Conclusion** The use of a TAT is a safe and effective way to reduce the duration of PN required in patients with CDO. This infers a significant cost saving per patient, a factor that cannot be overlooked in this period of austerity.

**Keywords** Congenital duodenal obstruction · Parenteral nutrition · Transanastomotic tube · Cost analysis · Cost saving

## Introduction

Congenital duodenal obstruction (CDO) occurs primarily due to the anatomical abnormalities of duodenal web (DW), duodenal stenosis (DS) or complete duodenal atresia (DA). Neonates presenting with CDO require surgery to relieve this mechanical obstruction prior to commencing enteral feeding. The commencement and establishment of enteral feeding following CDO repair can vary significantly [1] as often the obstructed proximal duodenum is dilated and has disturbed transit [2]. Early enteral feeding in surgical neonates has been shown to reduce hospital stay [3] and

a method of achieving this in patients after CDO repair is intra-operative placement of a trans-anastomotic tube (TAT).

The intended purpose of a TAT is to bypass the dilated dysfunctional segment of duodenum and the anastomosis, thereby allowing early introduction of enteral feeds. Furthermore, TAT placement enables replacement of nasogastric losses beyond the anastomosis, thereby minimising electrolyte imbalance through enteral loss. The main concerns in relation to TAT use are displacement, either proximal to the anastomosis or in entirety, and perforation. While these risks have been reported by other groups [4], there is no published evidence supporting an absolute contra-indication to TAT use in CDO.

The classical alternative to TAT placement is the siting of a central venous catheter and administration of parenteral nutrition (PN). The risks of PN are well recognized and include central line associated sepsis, cholestasis and thrombosis. Previous studies have shown that TAT use reduces the need for parenteral nutrition (PN) in children with CDO [4] and also that children with CDO who do not require PN have a lower rate of post-operative sepsis [5].

✉ Rachel Harwood  
Rachel.Harwood@liverpool.ac.uk

<sup>1</sup> Department of Paediatric Surgery, Royal Manchester Children’s Hospital, Manchester University NHS Foundation Trust, Manchester, UK

<sup>2</sup> University of Liverpool, Liverpool, UK

<sup>3</sup> University of Manchester, Manchester, UK

Whilst patient safety and clinical benefit remain the most important factors in the decision making process around any treatment modality, economic factors must also be acknowledged. The National Health Service is under huge financial pressure and the NHS net deficit is predicted to be £30 billion in 2020/2021 [6]. It is, therefore, imperative that clinicians take into account the cost impact of their chosen management plan.

Low and middle income countries are also under significant financial pressure for healthcare. The provision of parenteral nutrition has long been recognized as a substantial determinant of outcome of neonates with intestinal atresias [7] and gastroschisis [8]. Reporting the use of TAT and its economic implications, alongside the safety of its use, has the potential to improve the morbidity and mortality of neonates with CDO born in these countries.

Here, we report our experience of post-operative management of infants following CDO repair with and without the use of a TAT, paying specific attention to the monetary cost of feeding and supplementary nutrition from the time of surgery to the attainment of full oral or NG feeds. Our hypothesis was that TAT placement reduces the cost of post-operative nutrition provision in infants following CDO repair.

## Methods

A retrospective case-note review of all patients admitted to a single institution with CDO between 2004 and 2014 was performed. Patients were identified through operating theatre coding records, and information collated from case notes and hospital electronic records. Data collected included gestation, co-morbidities, age at surgery, anatomical malformation identified at surgery, operation performed [enterotomy and duodenoplasty (EDP), duodeno-duodenostomy (DD) and duodeno-jejunostomy (DJ)], placement or omission of TAT, central venous access and morbidity and mortality. Patients below 1.5 kg birth weight were excluded as they followed a much more conservative feeding regime as per the local neonatal unit policy.

The anatomical abnormality was determined intra-operatively and is described as duodenal web (DW), duodenal stenosis (DS) or duodenal atresia (DA). The decision to place a TAT was at the discretion of the lead surgeon. A varying opinion amongst surgeons in the department on the utility of TATs meant that the decision of whether a TAT should be placed was determined by the operating surgeon in all neonates over 1.5 kg. TATs were generally avoided in neonates under 1.5 kg in weight due to concerns about perforation in this smaller group.

The TATs (6F 125 cm, XRO paediatric duodenal silicone tube, Vygon, France) were placed intra-operatively.

They were fixed to the cheek of the neonate using duoderm (a piece placed directly onto the cheek to avoid pressure damage and a piece over the TAT onto the underlying duoderm to ‘sandwich’ the TAT). An NG tube was sited in all patients through the contralateral nostril and both tubes were fixed and labelled.

In cases where a TAT was placed, the NG losses as well as hourly feeds were given via the TAT as a slow gravity bolus in the immediate post-operative period. The rate of increase of feed volume was tailored to the individual patient following daily clinical assessment by the lead surgeon, rather than by unit policy. Full volume enteral feed was considered to be 150 ml/kg/day. Once full post-anastomotic feeds were achieved and tolerated for approximately 24 h, feeds were gradually altered to being given by mouth or by the NG tube. If there were low volumes of NG aspirates then oral bolus feeds of 5 ml 3 hourly were commenced and increased and this volume was taken off the TAT feeds. If there were ongoing moderate NG aspirates, pre-anastomotic feeds were introduced more slowly, using hourly NG feeds according to how well the neonate tolerated this.

When a TAT was not placed, pre-anastomotic feeds were commenced in the same fashion, using volume of NG aspirates as a guide to when feeds could be commenced, with an approach that < 10 ml NG aspirate in 24 h was acceptable.

Central venous access, if deemed necessary, was preferentially placed in the form of a peripherally inserted central catheter (PICC) with a tunnelled single lumen central venous catheter (CVC) as second choice.

The decision to commence PN was made jointly by the surgical and neonatal intensive care team and PN was reduced in line with patient’s tolerance of increasing enteral feed.

Cost calculations were performed using data collected from the hospital pharmacy team. PN was calculated to have a mean cost of £125 per patient per day with each bag being individually made for the patient in hospital. The current cost of PN was used for all patients to ensure that the cost calculations are relevant to the neonates currently being cared for with CDO. Enteral feed was preferentially expressed breast milk (EBM). The most expensive neonatal formula given in our unit is Hydrolysed Nutriprem at a cost of £0.60 per 90 ml. Case note analysis did not reveal the type of enteral feed given to each patient. An assumption has, therefore, been made in this work that all babies received Nutriprem feeds, in order to allow calculation of the most expensive enteral support possible. The contemporaneous cost of feed and PN was utilised to reflect the current cost of nutritional support for these neonates.

Statistical analyses were performed using SPSS software on an intention to treat basis. Two-tailed Mann–Whitney *U* test is used for non-parametric continuous data and

Chi-squared for categorical data. A  $p$  value of less than 0.05 was considered statistically significant.

## Results

71 patients eligible for inclusion in the study were identified. 12 of these patients were subsequently excluded. 9 patients' notes were not available for review, 1 patient died pre-operatively and 2 patients died in the immediate post-operative period due to cardiac co-morbidity. 6 neonates under 1.5 kg had CDO during the study period, only one of whom had a TAT placed. These neonates have not been included in the analysis for the aforementioned reasons.

Data are presented in Table 1. Patients were divided into two groups: TAT vs no TAT. There was no significant difference between the two groups with regards to gender, gestation, birth weight or duodenal abnormality. One patient in the TAT group had Trisomy 21. Frequency of central venous line placement and commencement of PN were not significantly different between groups.

In our group, 5 (14%) patients had an unintentional TAT displacement or removal. In no case was a TAT replaced in the immediate (< 2 weeks) post-operative period. Infants were converted from post-anastomotic to pre-anastomotic feeding regimes and enteral feed volumes continued to be increased as tolerated.

Whilst the difference in time taken to reach full pre-anastomotic enteral feeds is not statistically significant groups, PN was used for a significantly shorter duration in patients who had a TAT placed during surgery. This difference

created a significant reduction in the cost of post-operative nutritional support of £622.26 per patient, representing a 44.8% reduction in nutrition costs.

## Discussion

According to The Commonwealth Fund, the UK already offers the best value healthcare in the world [9], and indeed when compared to other high-income countries, the UK ranks first in terms of overall healthcare system performance when variables including care process, access to care, administrative efficiency, equity and healthcare outcomes are considered [10]. However, as healthcare providers, we are tasked with providing more cost effective, safe care. The NHS 5 year forward view highlights a growing financial sustainability gap, stating that the gap between resources and patient need will be nearly £30 billion a year by 2020/2 [11]. The Government of the United Kingdom (UK) has pledged to make £5 billion efficiency savings in the NHS by 2020 [12]. This central effort to bridge the sustainability gap is in itself not sufficient to maintain the NHS in its current form, and, therefore, it is incumbent on all members of the workforce to improve efficiency and cost effectiveness where possible. The situation in the UK is not unique. Compared with other high-income countries including the USA, Germany, Denmark and Canada, the UK spends less per capita on healthcare [10] yet US citizens believe that healthcare costs are too high [13].

Whilst in the overall expenditure of any healthcare system, paediatric surgery is not a specialty with a large

**Table 1** Demographic data and analysis of post-operative timing and costs of nutrition

	TAT ( $n=37$ )	No TAT ( $n=22$ )	$p$ value
M:F (%)	12:25 (35:65)	10:12 (45:55)	0.57
Median gestation in weeks (IQR)	38 (35–39)	36.5 (35–38)	0.25
Median birth weight in kg (IQR)	2.85 (2.22–3.31)	2.64 (2.34–2.89)	0.17
Median age at operation in days (IQR)	4 (2–7)	3.5 (2–7)	0.98
Abnormality, DW:DS:DA (%)	9:8:20 (24:22:54)	5:3:14 (22.7:13.6:63.6)	0.70
Operation, EDP, DD, DJ (%)	8:20:9 (22:54:24)	2:16:2 (9:72:9)	0.15
PICC line placed (%)	23 (62)	16 (73)	0.57
CVC placed (%)	9 (24)	3 (14)	0.51
Patients treated for line sepsis	7 (19)	4 (18)	1.00
Post-operative PN			
Time to commence enteral feeds in days (IQR)	4 (2–5)	7 (3–11)	0.02
PN administered (%)	26 (70)	19 (86)	0.16
Median duration of PN administration in days (IQR)	6 (0–11)	12 (8–19)	0.006
Median cost of PN in £ (IQR)	750 (0–1375)	1500 (1000–2375)	0.006
Median total cost of nutrition in £ (IQR)	765.26 (38.36–1404.56)	1387.52 (1008.23–2363.08)	0.015
Median time from surgery to full pre-anastomotic feeds in days (IQR)	12.5 (9–19.25)	16 (11.5–26.5)	0.12

budget, the incumbent costs for departments providing care is significant. Whilst the cost savings that are reflected here are small compared to the overall cost of care, we find that making a small, safe change to management can result in a significant percentage saving. If similar small, but effective, changes can be made in other common conditions, the savings become significant to the NHS budget.

The cost saving and reduction in need for PN is even more relevant in low and middle income countries where resources are scarce and provision of PN can be challenging, with high rates of sepsis causing mortality in infants with duodenal atresia [14].

CDO is a common cause of neonatal bowel obstruction and is associated with a mortality rate of up to 13% [14]. Intra-operative TAT placement provides a method of bypassing a new anastomosis to allow recycling of gastric aspirates via the TAT, thereby reducing electrolyte disturbance and minimising fluid balance derangements. The TAT also provides a conduit through which early enteral feed can be introduced. By using the TAT, an often dilated and dysfunctional proximal duodenum is bypassed and feeds can be increased relatively rapidly.

In patients with CDO without co-morbidity, establishing full pre-anastomotic enteral feeds is frequently the determining factor in the total length of inpatient stay on the neonatal unit. Co-morbidities including cardiac disease, chromosomal anomalies and prematurity can clearly have a detrimental impact on length of stay; it is beyond the remit of this paper to further explore these issues. Whilst it is widely accepted that the preferred source of nutrition for infants is breast milk [15], any form of enteral nutrition is preferred to PN. This particularly relates to the risks surrounding PN administration which include central venous access placement, line sepsis and PN-related cholestasis.

Previous studies reviewing the use of TATs in the management of CDO have found that they can reduce both rates of sepsis [4] and the rate of PN-associated cholestasis [16]. Although there were fewer central lines placed in our TAT group vs our non-TAT group, we found no significant difference in the frequency of CVL placement between groups and no statistical difference in the rates of post-operative line sepsis.

76% of neonates were commenced on PN, some pre-operatively, and this was continued after their CDO surgery, despite those with a TAT commencing enteral feeds a median of 4 days after surgery. There was a significant reduction in the duration of post-operative PN administration in the TAT group, although there was no significant difference in time to full pre-anastomotic feeds. Whilst other studies have reported this finding [17], it is not necessarily a surprise that the time to full pre-anastomotic feeds is not reduced. The TAT does not act to improve the dysfunction of

the proximal duodenum that is generally responsible for feed intolerance, but instead bypasses the dysfunction.

We recognize that a high proportion of neonates had an intra-operative central venous line placed at the time of CDO surgery. However, the data presented here support the notion that early operation for CDO combined with TAT placement could negate the requirement for PN in some of these neonates and, therefore, also the need for central venous access. Half of the patients in the TAT group received PN for less than 1 week. A strong argument could be made that there is no requirement at all for placement of central venous access in this group with the subsequent benefit of avoidance of line sepsis associated complications and we no longer routinely place a PICC or CVC for neonates with CDO.

The total duration and cost of PN use was significantly shorter in the TAT group, contrary to previous studies [17]. This is despite the patients being analysed on an ‘intention-to-treat’ basis, thereby including the 14% of patients who lost their TAT prior to achievement of full pre-anastomotic feeds. This finding strongly supports the benefit of TATs in all healthcare settings and may be most relevant to neonates with CDO in low and middle-income countries. The cost difference in terms of nutrition provision between the TAT and non-TAT groups is understated in this study. The retrospective nature of this work gave rise to difficulty in determining the precise feed used for enteral nutrition in each case. It was, therefore, assumed that the most expensive formula was given in every case so as not to under-represent the cost implications of not placing a TAT.

TATs can be associated with complications, notably dislodgement, with a rate of 14% in this cohort. Due to this rate of dislodgement the nursing education program teaches the management of TATs and we are reviewing the effectiveness of this educational change. There is a risk of perforation secondary to TAT placement. The rates of this are low and are represented in the literature by case studies [18]. There were no cases of perforation in our cohort.

Our study is not intended to be a full cost analysis of a patient’s stay and as such does not include additional costs that may be incurred. These may include the need for more frequent electrolyte measurements in patients on TPN, the duration of respiratory support and the total number of bed days. Whilst this is a limitation of the study, the inclusion of these factors could dilute the findings of the cost of nutrition in this heterogeneous group of patients.

## Conclusion

In infants over 1.5 kg with CDO the post-operative cost of nutrition is significantly reduced by 44.8% with the use of a TAT. The risk of TAT placement in these patients is primarily that of dislodgement, with no cases of perforation in this

cohort. With financial restrictions concerning all healthcare systems it is essential that all cost-saving measures possible are utilised in order to protect the service we provide, however small an individual saving that measure may produce.

**Acknowledgements** R. Harwood has received a research grant from Alder Hey Children's Kidney fund from August 2017–August 2018 and from Kidney Research UK from August 2018–August 2020 (Grant number TF\_010\_20171124).

### Compliance with ethical standards

**Conflict of interest** There are no conflicts of interest in any of the authors who contributed to this study, either financially or otherwise. R. H declares no conflicts of interest, J. F. Horwood declares that he has no conflict of interest, V. Tafilaj declares that she has no conflict of interest, R. Craigie declares that he has no conflict of interest.

**Human and animal rights statement** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. As this is a retrospective study and there is no inclusion of individually identifiable patients, formal consent was not required and was therefore not requested.

### References

1. Cho MJ, Kim DY, Kim SC, Namgoong JM (2017) Transition from laparotomy to laparoscopic repair of congenital duodenal obstruction in neonates: our early experience. *Front Pediatr* 5:203
2. Takahashi A, Tomomasa T, Suzuki N, Kuroiwa M, Ikeda H, Morikawa A et al (1997) The relationship between disturbed transit and dilated bowel, and manometric findings of dilated bowel in patients with duodenal atresia and stenosis. *J Paediatr Surg* 38(8):1157
3. Ekingen G, Ceran C, Guvenc BH, Tuzlaci A, Kahraman H (2005) Early enteral feeding in newborn surgical patients. *Nutrition* 21(2):142–146
4. Hall N, Drewett M, Wheeler R (2011) Transanastomotic tubes reduce the need for central venous access and parenteral nutrition in infants with congenital duodenal obstruction. *Pediatr Surg Int* 27:851–855
5. Bishay M, Lakshminarayanan B, Arnord A (2013) The role of parenteral nutrition following surgery for duodenal obstruction or stenosis. *Pediatr Surg Int* 29:191–195
6. Murray R, Imison C, Jabbal J (2014) Financial failure in the NHS—what causes it and how best to manage it. The King's Fund, London
7. Osifo OD, Okolo CJ (2009) Management of intestinal atresia: challenges and outcomes in a resource-scarce region. *Surg Pract* 13(2):36–41
8. Marshall Niles SG, Mitchell-Fearon K, Gill MI, DeSouza CJ, Fearon IC, Abel CA et al (2017) Mortality-related factors in gastroschisis—a Jamaican perspective. *J Pediatr Surg* 52(4):530–533
9. Davis K, Stremikis K, Squires D, Schoen C (2014) Mirror, mirror on the wall, 2014 update: how the U.S. Health Care System Compares Internationally. The Commonwealth Fund Report
10. Schneider EC, Sarnak DO, Squires D, Shah A, Doty MM (2017) Mirror, mirror 2017: international comparison reflects flaws and opportunities for better U.S. Health Care. The Commonwealth Fund Report
11. Five Year Forward View (2014) NHS England
12. Lord Carter of Coles (2015) Review of operational productivity in NHS providers: Interim report. Department of Health, UK
13. Vogenberg F, Santilli J (2018) Healthcare trends for 2018. *Am Health Drug Benef* 11(1):48–54
14. Rattan K, Singh J, Dalel P (2016) Neonatal duodenal obstruction: a 15-year experience. *J Neonatal Surg* 5(2):13
15. Braeggar C, Decsi T, Dias J, Hartman C, Kolack S, Koletzko B et al (2010) Practical approach to paediatric enteral nutrition: a comment by the ESPGHAN committee on nutrition. *J Pediatr Gastroenterol Nutr* 51(1):110–122
16. Jiang W, Lv x, Xu X, Geng Q, Zhang J, Tang W (2015) Early enteral nutrition for upper digestive tract malformation in neonate. *Asia Pac J Clin Nutr* 24(1):38–43
17. Ruangtrakool R, Mungnirandar A, Laohapensang M, Sathornkich C (2001) Surgical treatment for congenital duodenal obstruction. *J Med Assoc Thai* 84(6):842–849
18. Sun S, Samuels S, Lee J, Marquis J (1975) Duodenal perforation: a rare complication of neonatal nasojejunal tube feeding. *Pediatrics* 55(3):371–375