COST-BENEFIT ANALYSIS FOR DIRECT VISUAL OBSERVATION OF NASOGASTRIC ENTERAL FEEDING TUBE PLACEMENT

Rhodri JK. Saunders[1] and Audrey A. Ozols[2]

1. Coreva Scientific, Freiburg, Germany; 2. Medtronic, Boulder, Colorado, USA

OBJECTIVES: Requirement for assisted nutrition is common in healthcare and is often achieved via an enteral feeding tube (EFT). Misplacement and use of an EFT in the respiratory tract can lead to serious patient harm and is a 'never event' for certain national health services. Standard EFTs are placed 'blind' and must be confirmed by X-ray. Here, cost-benefit of an EFT with a built-in camera is estimated.

METHODS: Comparison of direct visual observation (DVO) and blind EFT tube placement was performed using a decision tree. For each blind procedure, the EFT was placed correctly (pyloric 94.5% or postpyloric 60.4%), placed in the trachea (1.9%, range 1.5%-2.1%), or otherwise misplaced in the gastric tract. Misplaced EFTs were replaced, with replacement after a tracheal insertion having a misplacement rate of 32%. A mean of 1.4 and 1.8 X-rays per EFT were required to confirm pyloric and postpyloric placement, respectively. Pneumothorax incidence was 10.2% (6.9%-33.3%) after tracheal placement, with associated mortality being 14.3% (0.0%-44.4%). The DVO and standard EFTs cost $150 and $5, respectively, per tube. Confirmation X-rays cost $150 ($100-$300). Early studies indicate that each DVO placement takes 5.5 minutes, 45% required two attempts, no severe AEs occur, and no X-ray was used in 95% of cases.

RESULTS: Assuming reuse of the DVO-EFT, this methodology was cost saving. If each replacement required a new EFT, the methodology would likely be considered beneficial at a cost-benefit threshold $10,000 per pneumothorax avoided. DVO is cost-saving in this scenario if costs for care, provider time, and ICU are considered. Other AE rates require confirmation, but pneumothorax rates could be increased and the cost-benefit of DVO would still be realized under the current model conditions.

CONCLUSIONS: The incremental cost DVO is fully or partially offset by reduced X-ray use. Avoidance of radiation and saved time are additional benefits.

BACKGROUND

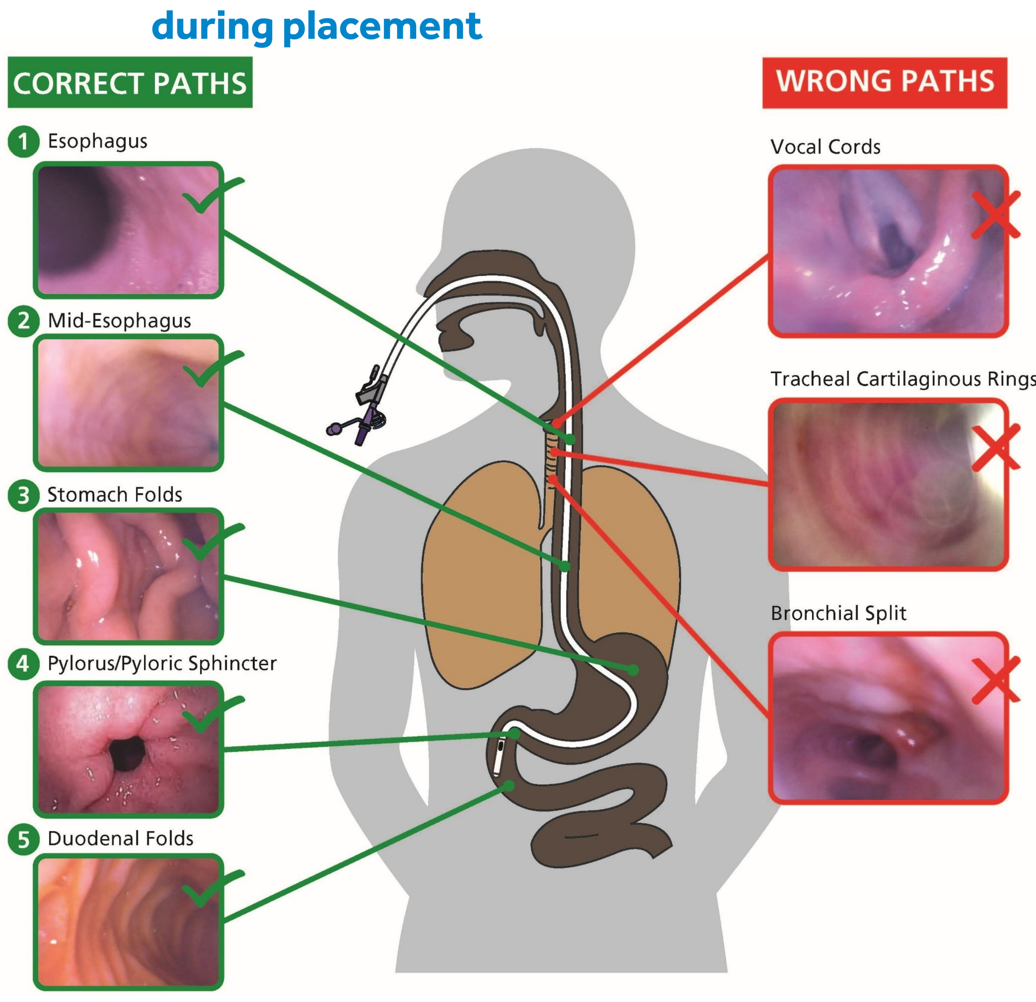
The Feeding Tube Awareness Foundation reports that >300 conditions can require use of an enteral feeding tube (EFT) [1]

- More than 1.2 million small-bore feeding tubes are placed each year in the United States of America (USA) [2]
- In 2007, 0.6% of short-stay hospital patients in the USA National Inpatient Sample received enteral nutrition (EN) [3]
- The majority of feeding tubes are placed blind, with rates of malposition reported to be in the range of 0.5-16 per 100 insertions [4]
- New technology allows for direct visual observation (DVO) of tube placement via a camera and external monitor (Figure 1)

AIM

To estimate the cost-benefit ratio of DVO during enteral feeding tube placement in the stomach

Figure 1. Direct visual observation of anatomical markers allows the path of the feeding tube to be observed during placement



METHODS

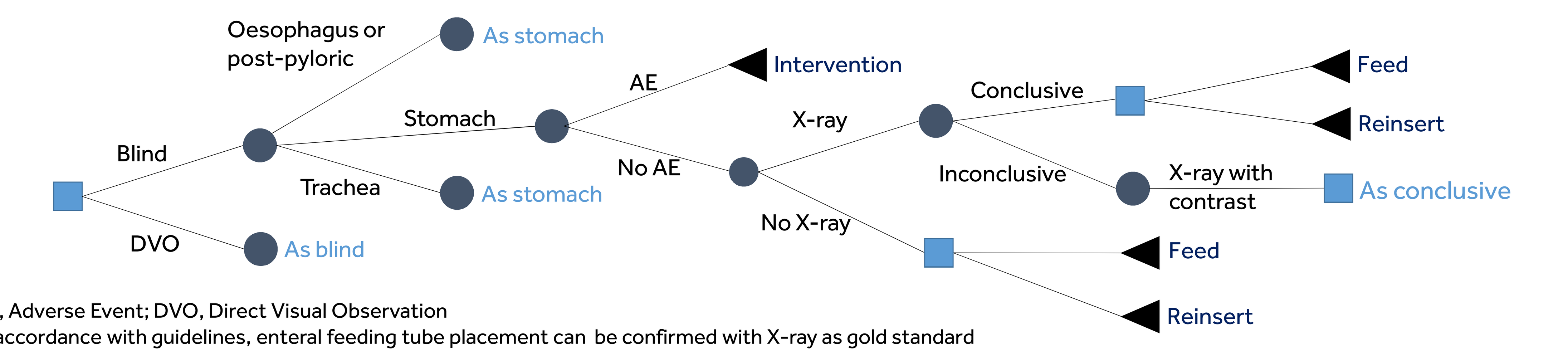
Data sources

- A structured search of PubMed was used to identify data on the incidence of EFT malposition and the associated adverse events and costs
- No head-to-head clinical trial comparing blind and DVO placement of EFTs exists
  - Blind placement data came from identified peer-reviewed literature
  - Two pilot studies provide data for DVO [5,6]

Decision tree model

A decision tree (Figure 2) was constructed to represent the stages of EFT insertion and placement confirmation in accordance with medical and modeling guidelines [7,8]

Figure 2. Model representing enteral feeding tube and verification thereof



AE, Adverse Event; DVO, Direct Visual Observation
In accordance with guidelines, enteral feeding tube placement can be confirmed with X-ray as gold standard

Base case

- Stomach placement of the EFT was modelled
  - 20% of patients were at greater risk of tracheal insertion, having been intubated or deeply sedated
- The EFT was misplaced in 5.50% (Blind) and 2.38% (DVO) of cases (Table 1), with fluoroscopy used after 3 insertions
  - No tracheal EFT placement was reported with DVO.[6] Given the study size (N = 42) the same ratio of total misplacement to tracheal misplacement as blind placement was assumed
- EFT placement and verification would take up to 48 hours, and adverse events reported in this time frame were considered to be related to EFT placement
  - Adverse events include pneumothorax, esophageal perforation, and incorrect (non-stomach) feeding
  - After tracheal insertion, the relative risk (RR) of tracheal reinsertion and pneumothorax increased , RR 15.8 and RR 2.3, respectively [10]
- Event costs were adjusted to 2015 USD using the USA healthcare-specific CPI

Sensitivity analyses

- Results from 1,000 simulations were performed
  - Cost-benefit was defined to be at a level of ≤$10,000 per pneumothorax avoided

Table 1. Base case model inputs and variance

Parameter, %/$ (SD)	Blind	DVO
Misplacement, %	5.50 (1.99) [9]	2.38 (2.35) [6]†
Tracheal placement, %	1.90 (0.19) [4]	0.82 (1.39)‡
Use of X-ray, %	100 (10)	5 (5) [7]
EFT cost, $	5 (0.5)	150 (15)
X-ray cost, $	179 (17.9) [11]	
Fluoroscopy cost, $	223 (48) [12]	
Pneumothorax, $	27,399 (2,700) [13]	

DVO, Direct Visual Observation; EFT, Enteral Feeding Tube; SD, Standard Deviation.
† There were no misplacements in 31 cases after training with DVO was complete and 1 misplacement during the 11 training cases; ‡ None reported, assumed to be at same ratio as Blind

RESULTS

Use of DVO increased the percentage of patients being fed correctly within 3 insertion attempts from 98.84% to 99.65%

- For placement (Table 2), patients required a mean of:
  - Blind: 1.22 insertions and 1.28 X-rays
  - DVO: 1.10 insertions and 0.06 X-rays
- Pneumothorax was reduced with use of DVO from 2.7 cases per 1,000 to 1.4 cases per 1,000
- Potential for feeding into the lung was 58.6% lower with DVO
- Costs with DVO were $97 lower than with blind placement, $215 versus $312
- DVO dominated (was cost saving and safer than) blind placement, with a saving of $77,360 per pneumothorax avoided

Table 2. Base case results

Outcome	Blind	DVO
Correctly fed, %	98.84	99.65
EFT insertions, N per patient	1.22	1.10
X-rays, N per patient	1.28	0.06
Pneumothorax, %	0.27	0.14
Death, %	0.04	0.02
Total cost, $	312	215

DVO, Direct Visual Observation; EFT, Enteral Feeding Tube

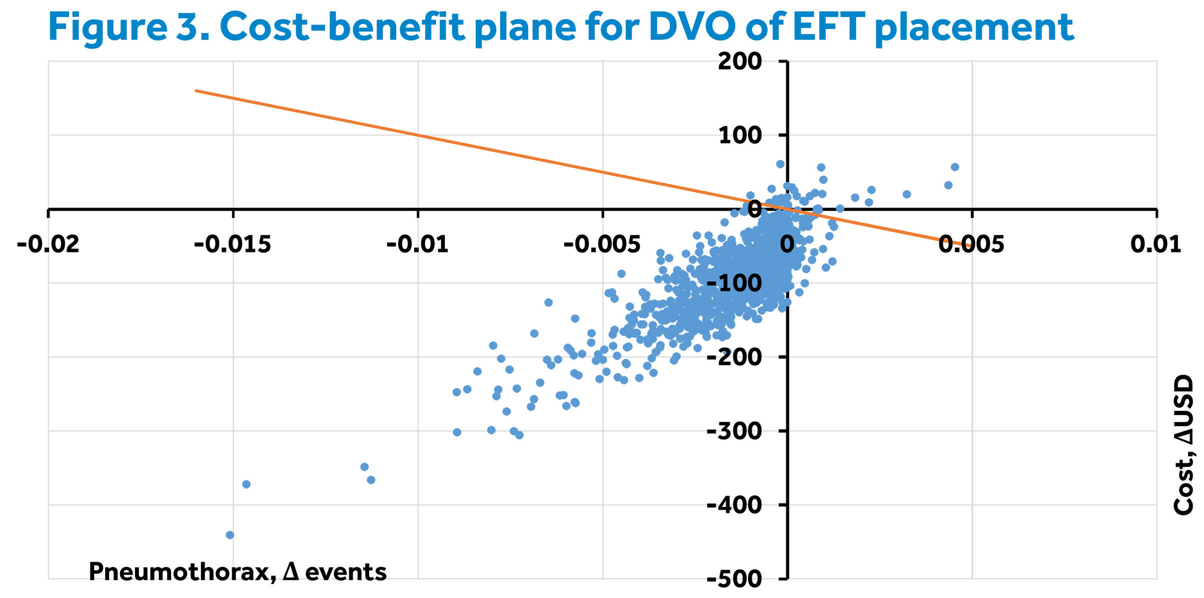
Outcome drivers

- Cost was driven by physician trust in DVO placement, interpretation of X-ray, and cost of DVO tubes and X-rays
- Correct feeding was driven by correct x-ray interpretation and the percent of blind tube placements confirmed by X-ray

Sensitivity analysis

- DVO dominated blind placement in 87.0% of simulations
- 11.5% of simulations were in the cost-benefit plane (Figure 3), in total DVO would be considered a cost-benefit as <$10,000 per pneumothorax avoided in 97.6% of cases

Figure 3. Cost-benefit plane for DVO of EFT placement



DVO, Direct Visual Observation; EFT, Enteral Feeding Tube. Orange line at $10,000 per pneumothorax avoided

Scenario analyses

- Considering nurse time at $48 per hour, [14] or reuse of the original EFT for reinsertion, the cost saving with DVO increased to $151 and $110, respectively
  - Including both nurse time and reuse of the EFT together, the cost saving reached $163, with DVO having a cost-benefit in 99.8% of simulations
  - In addition, if DVO was available at $200, it would be considered a cost-benefit in 99.3% of simulations
- Trebling the DVO misplacement rate (7.1%, 2.5%) resulted in DVO being a cost-benefit in 96.9% of simulations
- Excluding training data,[6] there were no EFT misplacements with DVO, giving a saving of $154 and making DVO dominant in 90.8% and a cost-benefit in 97.8% of simulations

CONCLUSIONS

- Our estimates indicate that compared with blind placement, direct visual observation (DVO) of enteral feeding tube placement:
  - Will likely reduce the incidence of pneumothorax
  - Would probably be considered at a positive cost benefit to healthcare payers in the USA setting
- A reduction in X-rays required with DVO results in savings in both nurse time and direct hospital costs

ACKNOWLEDGMENTS

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