

Research

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Cost-Effectiveness of the Sucralfate Technetium 99m isotope Labelled Esophageal Scan to Assess esophageal Injury in Children after Caustic Ingestion

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ABSTRACT

Background: Ingestion of caustic material by children is a considerable health problem. The ^{99m}Tc-labelled sucralfate esophageal scan proved to be an accurate method to identify injury to the esophagus after caustic substance ingestion. The purpose of this study was to calculate the cost-effectiveness of a sucralfate scan as compared to the gold standard of using endoscopy under general anesthesia. A secondary outcome was to assess the positive predictive value of the sucralfate scan.

Methods: A 10-year retrospective medical folder audit was conducted of all children admitted to our hospital with a history of caustic ingestion who underwent a sucralfate scan to identify evidence of caustic esophageal injury/inflammation. The patients who had a negative sucralfate scan were assessed as having no significant injury and were discharged without further investigation or management. The patients with a positive result went for a subsequent endoscopy.

Results: 234 patients were included. The total costs saved by performing a sucralfate scan only were R 446, 964.00 (South African Rand) in 234 patients. The positive predictive value of performing a sucralfate scan is 47.3%.

Conclusion: A sucralfate scan as primary diagnostic method for caustic injury proved to be cost-effective and with less chance of complications.

KEYWORDS: Sucralfate; Caustic; Esophageal Injury; Cost-Benefit Analysis.

INTRODUCTION

Ingestion of caustic material by children continues to be a significant problem in developed countries.¹ Over 200,000 of such cases were reported in the United States in 2009 alone,² of which 807 required hospitalization.³ Accurate figures on the incidence of this type of injury in developing countries are not available however the large number of children requiring esophageal replacement for caustic injury indicates that this is a serious public health problem.⁴

The extent of the esophageal injury after ingestion of caustic substances has been determined using different methods, such as traditional radiology, CT-scan, ultrasound and endoscopy.⁵

In 2001, Millar et al. showed the accuracy of a ^{99m}Tc-labelled sucralfate scan in de-

tecting esophageal injury after ingestion of caustic substances.⁶ When sucralfate comes into contact with damaged tissue it adheres. This has been part of its efficacy in the treatment of peptic ulcer. Sucralfate mixed with radioactive technetium 99m will bind to the damaged area, which will then be visible as a hot spot on the scan.⁶ It has been our practice since validating the sensitivity of the sucralfate scan to perform a scan as a screening investigation after a child has been admitted with a history of caustic ingestion with or without clinical evidence of buccal or pharyngeal mucosal injury. Endoscopy to determine the extent of the damage was only performed after a positive scan. If the sucralfate scan showed no sucralfate adherence to the esophageal mucosa endoscopy was not performed since the negative predictive value of the sucralfate scan has proven to be 100%.⁶

Since 2001 at the Red Cross War Memorial Children's Hospital (RCH) in Cape Town, the initial standard diagnostic test in children who have ingested a caustic substance has been a radio-nuclear sucralfate test. It is preferred over endoscopy under general anesthesia as the latter is an invasive method and general anesthesia in children is associated with morbidity and mortality.⁷

The type and amount of the caustic substance ingested are important factors determining the extent and severity of the injury and the incidence of complications.^{8,9} There is still doubt which of the two, acidic or alkali ingestions, result in more severe injuries.^{9,10}

The main purpose of this review report was to calculate the cost-effectiveness of a sucralfate scan as compared with standard endoscopy. A secondary aim was to determine the positive predictive value of the sucralfate scan with that of fiberoptic upper gastrointestinal endoscopy. We also made a comparison between the result of the scan and the nature of the swallowed substance, and the result of the scan and the length of stay in the hospital.

MATERIALS AND METHODS

A 10-year retrospective medical folder audit was conducted of all children with caustic injuries to the esophagus who underwent a sucralfate scan in RCH from January 2003 to June 2013. Local ethics and research committee approval were obtained.

The nuclear medicine department of the RCH identified eligible patients. The medical records of these patients were searched for information on date of injury, date of admission, age at admission, date of procedure, date of discharge, result of the sucralfate scan, complications and whether or not they had an endoscopy, including result.

When the patients had a negative result on the sucralfate scan (thus no significant injury), they did not have a subsequent endoscopy. The result of the sucralfate scan was considered positive if we were able to see adherence of the radioactive

isotope in the esophagus on the scan.

The result of the sucralfate scan was compared to the nature of substance swallowed and the length of stay was compared to the pH values of the substances. The finance department of the RCH provided costs of endoscopy, broken down for specialist, procedure, operation room fees and costs of anesthetics.

Data Analysis

The positive predictive value of the sucralfate scan was calculated using the endoscopy as criterion standard. Because an endoscopy was not performed if the outcome of the scan was negative, calculating the sensitivity, specificity and negative predictive value of the scan were not possible.

Categorical variables were compared using Fisher exact tests. Length of stay was compared for children with and without abnormal mucosa using the Mann-Whitney U test.

RESULTS

Two hundred and seventy-nine eligible patients were identified. Thirty-five medical folders were missing, however, and four medical records did not involve a history of caustic ingestion. For another four patients an endoscopy was not documented, in spite of their positive sucralfate scan. Two patients underwent endoscopy even though there was no evidence of them ever having had a sucralfate scan in their medical folder. These 45 patients were excluded from analysis. The median age of the remaining 234 children was 2 years (IQR 1.5 to 2.1).

143 patients (61.1%) had a negative result on the sucralfate scan, and therefore did not undergo a subsequent endoscopy. The cost of performing an endoscopy was estimated at 4,867.00 Rand while the cost of performing a sucralfate scan was estimated at 1,285.00 Rand. Therefore, the cost saving of performing a sucralfate scan without performing a subsequent endoscopy will save 3,582 Rand per patient. If these patients would have been assessed with endoscopic diagnostic procedure, this would have resulted in a cost of 143 x 3,582.00 Rand more. This on calculation resulted in an estimated saving of 512,226.00 Rand in these 143 patients.

The sucralfate scan in 48 children was false positive; it showed mild adherence in the esophagus while the endoscopy did not show any damage. If these patients would have been treated according to the criterion standard diagnostic procedure, the costs of the sucralfate scan would have been saved, amounting to 48 times 1,285.00 Rand, which is 61,680.00 Rand.

The total costs saved by performing a sucralfate scan as primary diagnostic procedure instead of performing an endoscopy are 446,964.00 Rand (approximately 40 000 USD) in 234 patients.

Not every patient received a subsequent endoscopy. Therefore we could only calculate the positive predictive value. Of 91 positive scans, 48 proved to be false positive. This leaves us with 43 true positive scans and a positive predictive value of $43/91 = 47.3\%$.

In 14 cases the substance swallowed was unknown. Of the remaining 220 cases, 143 (65 percent) had damage to the esophagus due to cleaning agents. In 28 cases the pH value could not be determined. Twenty-one of the latter had swallowed potassium permanganate crystals ($n=21$). The remaining cases were divided in acidic ($\text{pH}<6$), alkaline ($\text{pH}>8$) and neutral ($6<\text{pH}<8$). These cases were compared to the result of the scan in terms of normal and abnormal mucosa (Table 1). There was no significant difference in mucosal damage between the groups ($P=0.80$). Length of stay in the acidic and potassium permanganate groups was significantly longer ($P=0.044$) than in the alkaline and neutral groups. The most common complications seen were strictures ($n=7$) and pneumonia ($n=5$).

		Result	
		Normal Mucosa (N=129)	Abnormal Mucosa (N=84)
Type	Acidic	9 (56.2%)	7 (43.8%)
	Alkaline	95 (62.5%)	57 (37.5%)
	Neutral	14 (58.3%)	10 (41.7%)
	Potassium Permanganate	11 (52.4%)	10 (47.6%)

Table 1: Sucralfate scan results versus the nature of ingested substance.

20.3% of the children with a normal mucosa after sucralfate scan were discharged home on the same day they were admitted, compared to 1.1% in the abnormal mucosa group (Table 2). Four children with normal mucosa were admitted longer than 3 days; one child for a week because of drooling, refusing feeds and fever. Two children developed pneumonia, and in one 5 months-old baby the mother had intentionally given the substance. Length of stay was significantly longer in children with abnormal mucosa compared to those with normal mucosa (Mann-Whitney U test, $p<0.001$).

		Result		Total
		Normal Mucosa	Abnormal Mucosa	
Length of stay	0	29 (20.3%)	1 (1.1%)	30 (12.8%)
	1-3	110 (76.9%)	72 (79.1%)	182 (77.8%)
	4-7	4 (2.8%)	12 (13.2%)	16 (6.8%)
	8 and more	0 (0%)	6 (6.6%)	6 (2.6%)
Total		143	91	234

Table 2: Sucralfate scan results versus length of stay.

DISCUSSION

The sucralfate scan seemed to be a cost-effective inves-

tigation in that we were able to avoid performing an endoscopy in over 50% of the patients admitted with a history of caustic substance ingestion. The sucralfate scan is a non-invasive procedure and in 143 children, no endoscopy was needed at all. This saved costs, avoided general anesthetics and avoiding endoscopy has all the clinical advantages of minimizing the potential morbidity of a general anesthetic and a fiberoptic endoscopy in a child and is of course less distressing for the children.

The costs for procedures in the OR are significantly lower than private hospitals because the RCH is a state hospital. The above costs did not include professional fees, which a patient pays at a private hospital. So the advantage in costs a sucralfate scan has would probably be even bigger considering the fact that the time to perform an endoscopy is longer and requires more specialized staff.

The predominant symptoms at presentation were usually mild gastrointestinal symptoms. This research, and that of others,¹¹ showed that one should be also alert for other complications of noxious substance ingestion. Respiratory complications such as pneumonia from aspiration and other potentially dangerous side effects of caustic ingestion, such as strictures or dysphagia, must also not be forgotten.

While in the literature there is still doubt on this issue,^{9,10} we found that alkaline substances were related to longer hospital stay, and thus probably caused more severe injury. However, alkaline substances did not have a significantly more damaged mucosa than acidic or neutral substances.

While sucralfate scans are able to identify microscopically damaged tissue; endoscopy is limited and only able to pick up macroscopic tissue damage. Oversensitivity has also been documented in our initial paper describing the use of sucralfate.⁶ Perhaps a number of false positive sucralfate scans could also be contributed to a longer time interval between the sucralfate scan and the endoscopy. Due to several logistic reasons, some patients underwent endoscopy more than one day after the sucralfate scan was performed. In these cases, very mild tissue damage may already have healed.

One of the limitations of this study is its retrospective nature, which accounts for several inconsistencies and for missing patient folders. A further limitation is that this study design did not cover any potential false negative sucralfate scans. However, none of the children who had a negative sucralfate scan developed any strictures, further symptoms or was re-admitted. Finally, the estimate of costs saved by doing a sucralfate scan as primary diagnostic method were calculated on rates for patients with medical insurance. The hospital does not have an overview of the individual costs of every anesthetic or equipment used, but uses standardized rates. Costs saved on the salary of medical specialist could also not be included in the cost calculations for the hospital. Thus there is a considerable underestimate of the overall cost.

The question remains whether endoscopy and/or a sucralfate scan are always indicated after ingestion of a caustic substance. It has been proposed to be unnecessary in asymptomatic patients as the injury then is most likely low-grade.¹²⁻¹⁴ Although these cases require monitoring, intervention can usually be avoided.¹⁵ However, it is well documented that patients without evidence of buccal or pharyngeal injury can have significant oesophageal mucosal injury.

Besides the diagnostic advantages, performing a Sucralfate scan may also have therapeutic advantages. It has an inhibitory effect on stricture formation by enhancing mucosal healing and suppressing stricture formation.¹⁶

In the future, more sensitive methods may become available. For instance, Eliakim and Koslowski have evaluated effectiveness of the pill-cam, a camera in the shape of a pill shooting frames 4 or 14 times per second, in detecting esophageal pathology. This has not yet been tested on patients with caustic ingestion, but may be promising.^{17,18} Since this article is intended to advocate cost saving, this method would not be a suitable alternative, for cameras are more expensive.

Another promising method is the ^{99m}Tc-Perchnetate scan, which yields a positive result when the injury in the esophagus is grade 2a or lower. In that case no intervention is needed.¹⁶ Lastly, ^{99m}Tc-PYP scintigraphy has been found sensitive and specific for the detection of caustic esophageal injury in small laboratory animals, but has not yet been tested on humans.¹⁹

The initial endoscopic grading of caustic injuries is the main factor predicting patient survival and functional outcome.²⁰ If the sucralfate scan is positive, a subsequent endoscopy still needs to be performed to assess the extent of damage and determine the grade of the injury.

More research has to be performed to determine the possibility of initial grading of the injury with a sucralfate scan. The amount of sucralfate attached to the lesions should be compared to the damage assessed by an endoscopy, performed shortly after the other.

In many homes, caustic solutions are still too often stored in unlabeled containers or drinking bottles stored on the ground floor and easily accessible by crawling toddlers, which children can drink or be given accidentally by other adults.^{21,22} Campaigns are required warning parents and caretakers not to put caustic solutions in accessible containers or bottles.

After this research, it can be concluded that the sucralfate scan is indeed a cost-effective method to assess damage to the esophagus in children after caustic substance ingestion. Other hospitals with considerable numbers of patients with caustic damage to the esophagus may want to consider using this method as well, since it minimizes the potential morbidity of using an endoscope.

CONFLICTS OF INTEREST: None.

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