Clinical effectiveness of bougienage for esophageal coins in a pediatric ED: a large case series

Evan H. Allie, MD a, Aaron M. Blackshaw, BS b, Joseph D. Losek, MD c, Rachel E. Tuuri, MD c,*

a Medical University of South Carolina Children’s Hospital, Department of Pediatrics Residency Program, Charleston, SC

b Medical University of South Carolina, College of Medicine, Charleston, SC

c Medical University of South Carolina Children’s Hospital, Department of Pediatrics, Division of Pediatric Emergency Medicine, Charleston, SC

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A B S T R A C T

Objective: To describe a tertiary care pediatric emergency department (PED) experience with bougienage for esophageal coins.

Methods: This was a large retrospective case series of children with esophageal coins presenting to a tertiary PED from January 2004 to October 2012. Bougienage eligibility criteria were medically stable, no prior gastro-esophageal surgery or disease, single coin, and witnessed ingestion within 24 hours. Abstracted data were age, signs and symptoms, coin type, management, efficacy, complications, returns, length of stay (LOS), and hospital charges. Main outcomes included procedural success and complications. Secondary outcomes included LOS and hospital charges.

Results: There were 245 patients with esophageal coins with 136/145 (94%) successful bougienage procedures and 109/109 (100%) successful surgical retrievals. There were 18 minor complications and 5 return visits for patients with bougienage. There were 10 minor and 2 major complications with surgical retrieval. Patients undergoing bougienage were 4 years (SD 2) vs 3 years (SD 3) for surgical retrieval. There was 632, 95% CI for the difference in means of $6,580 to $5,496 (P < .001). Mean LOS for successful bougienage was 137 minutes (SD 54) vs 769 (SD 535) for surgical retrieval. The difference in the means was 622, 95% CI for the difference in means of $723 to $541 (P < .001). Mean charges for successful bougienage were $984 (SD 576) vs. $7022 (SD $3132) for surgical retrieval. The difference in means was $6038, 95% CI $6,580 to $5,496 (P < .001).

Conclusions: Esophageal bougienage is safe and highly effective. It is also more time and cost efficient than other treatment options.

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1. Introduction

Foreign body ingestions are routinely managed in the pediatric emergency department (PED), with coin ingestions occurring most frequently [1–4]. Although many coins move through the gastrointestinal tract without difficulty, esophageal entrapment is common [1,2,5–7]. Lodged esophageal coins may cause pain, dysphagia, aspiration, respiratory distress, infection, and pressure mucosal erosions [2,3]. Prolonged entrapment may cause greater injuries including airway obstruction, esophageal strictures, perforation, and fistula formation [2,3,8–12]. Therefore, early care for an esophageal coin is imperative [2,3].

Treatment for children with lodged esophageal coins is dependent upon patient presentation and institutional practice. While 2-view chest radiographs are uniformly used to verify the identity and location of an esophageal coin, the duration from ingestion, presenting symptoms, and past medical history direct further management [13]. Expedient removal of esophageal coins in the operating room is the standard of care for any child with a history of esophageal disease, severe symptoms, multiple coins, and a prolonged or unknown duration from ingestion [14,15]. At most institutions, asymptomatic children undergo endoscopic coin retrieval [3]. Other techniques for removal include extraction by a Foley catheter under fluoroscopy or direct laryngoscopy with forceps retrieval [16–18]. Also, some facilities may use a brief period of observation for spontaneous coin passage [3]. Esophageal bougienage is another technique that uses a blunt Hurst dilator to advance an esophageal coin into a patient’s stomach.

Several observational studies have demonstrated that esophageal bougienage is efficacious and safe and a few have demonstrated that it is efficient and less costly in comparison to the aforementioned
management strategies [2,15,19–23]. Bougienage does not require anesthesia, takes seconds to complete, and reliably results in successful passage of a coin to the stomach without complications [2,22]. However, most facilities do not utilize bougienage as a primary management tool, likely because the body of research on this modality is modest.

Our primary objective was to report our PED’s 8-year experience with bougienage as a chief management strategy for recently lodged esophageal coins. Our secondary objective was to compare clinical outcomes and charges associated with bougienage to those with endoscopy, direct laryngoscopy, or Foley-retrieval.

2. Methods

2.1. Study design

We conducted a large retrospective case series of all children with lodged esophageal coins presenting to a tertiary care PED from January 2004 through October 2012. The Institutional Review Board of this institution approved this study.

2.2. Study setting and population

The study setting was an urban tertiary care PED and Level 1 Trauma Center has 22,000 annual visits and an 18% admission rate. In 2004, our PEM physicians began using the bougienage procedure for lodged esophageal coins. The following criteria must be met prior to bougienage: radiographic evidence of a single esophageal coin, witnessed ingestion within 24 hours, no previous esophageal or gastrointestinal anomalies or surgeries, and no respiratory distress. At our institution physicians must undergo training prior to performing the bougienage procedure, and all bougienage procedures require parental informed consent.

The bougienage device is a Hurst dilator (Fig. 1), which is a flexible push-type dilator with a rounded entrance tip. Hurst dilators (Medovations, Milwaukee, WI) are made of silicone, with a tungsten weight at the entrance tip, and do not use a guidewire. They are reusable for a 3-year duration. A dilator has a purchase cost of $137 to $392 according to size [24]. The current procedure charge for bougienage at our institution is $544.

Before the procedure, the dilator insertion length is measured as the distance from the patient’s nares to subxiphoid space and marked with tape. Table 1 shows our guideline for dilator size according to patient age. Anxiolysis may be considered, but is infrequently used because the procedure lasts less than a minute. As patients undergoing bougienage do not undergo sedation, there is no NPO requirement and intravenous access is not typically obtained. At the start of the procedure the child is wrapped in a sheet and placed in an upright, seated position with arms, legs, and forehead restrained from behind by an assistant. A water-based lubricant is applied to the dilator. Then the child’s mouth is opened and held open with a bite block positioned along the side of the child’s mouth. Next the dilator is rapidly placed in the oropharynx, gently advanced down the esophagus to the measured length, and quickly removed. Fig. 2 illustrates the steps for performing bougienage.

A second radiograph is obtained to determine coin passage. If the coin has not advanced, a repeat bougienage may be attempted. If the coin has entered the stomach, the child is observed briefly and discharged with monitoring for coin passage in the stool. As nearly all coins in the stomach pass through the gastrointestinal tract [3,25], the need to strain is suggested but is not mandatory. More importantly, caregivers are instructed to return for symptoms and signs that are worrisome for bowel obstruction or esophageal injury, although these have not been reported. Follow up X-rays, although not typically performed, but may be considered at 2 weeks if there is ongoing concern about a failure of coin passage.

Of note, our institution’s guidelines do not specifically prohibit the use of bougienage in children under 1 year, but the guidelines do not suggest a specific dilator size given the paucity of data in this age group. As a result many PED attendings at our institution choose to have children under age 1 undergo coin retrieval in the operating room. Specifically at our institution, children who are ineligible for bougienage undergo endoscopic coin removal by a pediatric surgeon. Less commonly, the surgeon will use forceps retrieval or fluoroscopic removal with Foley catheter. Follow-up for surgical patients is usually completed by telephone one week after the procedure.

2.3. Study protocol

A list of children seen at our facility from January 2004 to October 2012 with ICD-9 and E-codes for foreign body (FB) ingestion (I-933-938; E-912) and procedure charge codes for esophageal FB removal (9802) was generated from our hospital discharge database. The electronic medical records of each visit on this list were screened for study inclusion using these selection criteria: single coin ingestion, confirmed by radiographs, and treated in the PED. These exclusion criteria were used: multiple coins, non-coin FB, non-esophageal coins, or no radiographic evidence of esophageal coin. A random number code was assigned to each included case in order to perform de-identified data abstraction within 2 electronic chart systems.

We reviewed the medical records for each included patient visit. Scanned paper records were viewed in the Horizon Patient Folder system and clinic visits along with hospital charges were reviewed with the Oasis system. Before data abstraction, the authors developed an abstraction form and piloted it through a collective review of ten medical records. All authors were aware of the study objectives. Subsequently the first and second authors abstracted all included records. Further questions that arose during chart review were resolved by discussion and mutual agreement between all authors.

The following were abstracted from included charts: age, gender, duration from ingestion, coin type, esophageal location of coin, presenting signs and symptoms, bougienage eligibility, initial and subsequent management, procedural complications, length of stay, and hospital charges. Two-week return visits to the clinic or PED that were related to the initial coin ingestion and re-hospitalizations were abstracted along with associated hospital charges for these visits.

<table>
<thead>
<tr>
<th>Patient age (y)</th>
<th>Dilator size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &lt; 2 y</td>
<td>28F</td>
</tr>
<tr>
<td>2 &lt; 3 y</td>
<td>32F</td>
</tr>
<tr>
<td>3 &lt; 4 y</td>
<td>36F</td>
</tr>
<tr>
<td>4 &lt; 5 y</td>
<td>38F</td>
</tr>
<tr>
<td>≥ 5 y</td>
<td>40F</td>
</tr>
</tbody>
</table>

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Deidentified data were transcribed from paper forms into a secure online database.

Age was abstracted in years from age 1 and up and in months for children less than 1 year. Duration from ingestion was defined as time from ingestion until triage at our facility. Coin type was abstracted according to parental history for the patients undergoing bougienage and operative report for those undergoing surgical retrieval. Coin location was determined by review of radiographs and radiologist report. Investigators defined an upper esophageal location as at or above the thoracic inlet or clavicles, the middle esophagus as T-4 to the level of the aortic knob, and the lower esophagus as T-10 to the lower thoracic inlet. Bougienage eligibility was determined by PED guidelines described previously, with the one exception being that these study investigators decided to specifically categorize children <1 year of age as ineligible for bougienage. Investigators made this categorization because of the lack of dilator size recommendations for infants in our guidelines and due to limited published data on bougienage for infants with esophageal coins.

Procedural complications were defined as vomiting, failure to move the coin, gagging, oral abrasions, stridor, respiratory distress, aspiration, esophageal/gastric perforation, hypoxia, and cyanosis. Return visits were defined as a complication. For patients with 2-week return clinic or PED visits, we recorded additional complications of food refusal, failure to pass coin in stool, or drooling.

Length of stay (LOS) was defined as the time from PED triage to PED or hospital discharge. Additional time spent in follow-up clinic visits was not included in the LOS calculation, as this was not well documented. Hospital charges for each patient were calculated as the sum of charges recorded for the initial visit and charges for additional visits and hospitalizations.

The senior author re-abstracted 10% of included charts to assess reviewer concordance. Charts were selected for re-review at random. In total, 672 data points were re-abstracted from 25 charts and agreement was found on 658 data points. The percent of agreement was 97.9% with a 95% confidence interval for a single proportion of 96.9% to 99%. There was 100% agreement for charges and 96% agreement for hospital LOS. For the 14 data points with discrepancies, the data abstracted by the senior author were used.

All patients were divided into two main categories for comparison: patients undergoing successful bougienage and patients undergoing definitive management by a surgical retrieval, with the surgical category including those with a failed bougienage attempt. Additionally patients were subdivided into the following management subcategories for comparison: successful bougienage, unsuccessful bougienage, bougienage eligible but underwent surgery, and bougienage ineligible and underwent surgery.

2.4. Outcome measures

The primary outcome measures were success of chosen procedure, major complications, and minor complications. Additional outcome measures included hospital length of stay and total hospital charges.

2.5. Data analysis

We used descriptive statistics for age, complications, location, and coin type, and outcome measures for each management category and subcategory. The following demographic and outcome measures were compared between management categories and subcategories using a student’s t-test and 95% confidence intervals: age, LOS, and hospital charges for all related visits. We used Primer of Biostatistics (7th ed; McGraw Hill, Inc) to analyze the data.

3. Results

A total of 1125 charts were screened with 245 patients meeting inclusion criteria. There were 880 total patients excluded as follows: non-coin FB (463), coin below the lower esophageal sphincter (148),
no FB (183), airway FB (75), more than one coin (5), FB in other locations (3), and non-PED management (3). Fig. 3 outlines the case selection and outcomes according to management cohort.

The mean age was 3.4 years for all patients with 113 (46%) females. Fifty-six patients presented to our PED with a history of coin ingestion but were asymptomatic upon arrival, and 12 patients presented with parental suspicion for coin ingestion and were asymptomatic. One hundred and five patients were transferred from another facility for a lodged coin, and 51 of these were asymptomatic upon PED arrival. Collectively, 119 (48%) patients were asymptomatic at presentation. The remaining 126 patients presented with 138 signs and symptoms as follows: drooling (39), respiratory distress/wheezing/cough (22), dysphagia/throat pain (21), chest pain (16), emesis/gagging (19), abdominal pain (8), food refusal/decreased oral intake (5), stridor (3), fever (3), oral swelling (1), and fast heart rate (1).

Table 2 presents mean age, range, and standard deviation for each cohort. The most common coin location and type for all patients were upper esophagus 133 (54%) and penny 132 (54%). Table 3 presents coin type and esophageal location by cohort.

One hundred sixty-six of the 245 patients were eligible for bougienage. Of these, 137 bougienage procedures were attempted and 130/137 (95%) were successful. Of the 7 patients with failed bougienage, 6 had spontaneous passage of the coin into the lower GI tract prior to surgical retrieval. The seventh patient had spontaneous passage of the coin into the lower GI tract prior to surgical retrieval. This patient was included in the final analysis. Of the 79 patients who were bougienage ineligible, 71 had surgical retrieval and 8 underwent bougienage at the attending physician’s discretion. Of these 8 bougienage attempts, 6/8 (75%) were successful and 2 required endoscopy after bougienage failure. Table 4 provides details of the cases that met exclusion criteria but underwent bougienage. Of the 109 patients who had surgical retrieval, 95 underwent endoscopy, 9 Foley retrieval, and 5 direct laryngoscopy with forceps retrieval.

Of the patients with successful bougienage, 23 patients had complications. Twelve patients had vomiting or gagging and 5 had a repeat bougienage attempt. One patient had a brief episode of cyanosis without change in oxygen saturation. One patient returned to the PED due to abdominal pain and 3 had additional clinic visits. One patient had failure of coin passage beyond the pylorus and required endoscopic retrieval at 2 weeks.

Of the patients undergoing surgical retrieval, there were 10 minor and 2 major complications. Minor complications included 4 cases with failure to remove the coin on first attempt, 4 with conversion to another retrieval method, 1 transient hypoxia, and 1 oral abrasion. The 2 major complications included endotracheal tube dislodgement during coin retrieval and a traumatic esophageal diverticulum. The

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latter case had an unknown duration of coin lodgement and did not qualify for bougienage.

The mean age for the 9 patients with failed bougienage was 2.1 years compared to 4.1 years for the 130 patients with successful bougienage, with a mean difference of 2 years, 95% CI 0.5 to 3.4 (P < .001). Four children under 1 year of age underwent bougienage with 3 successful attempts. The unsuccessful attempt was on a 9-month-old with an unwitnessed ingestion and an unidentified type of coin located in the upper esophagus. This patient had a single attempted bougienage using a 28 F dilator. The details of the successful infant bougienages are as follows: an 8-month-old with an unwitnessed ingestion of an unidentified middle esophageal coin using a 26 F dilator, an 11-month-old with a witnessed ingestion of an upper esophageal penny using a 24 F dilator, and a 6-month-old with an unwitnessed ingestion of an unidentified upper esophageal coin using a 28 F dilator.

Table 4 presents mean, range, and standard deviations of age, LOS, and hospital charges for all patient management cohorts. The cumulative hospital charges for the one patient who required surgical removal of an intragastric coin after bougienage and failure of the coin to spontaneously move past the pylorus were $5564. Table 6 compares patient age, LOS, and hospital charges between patients with successful bougienage and those undergoing surgical retrieval. The patients who had successful bougienage were older, with a difference between means of 1.6 years, 95% CI 0.5 to 1.7, (P < .001). The patients with successful bougienage had a significantly shorter LOS, with a mean difference of 632 minutes, 95% CI −724 to −541, (P < .001). The hospital charges for the patients with successful bougienage were significantly less with a mean difference of $6039, 95% CI $−6606 to $−5533 (P < .001). Table 7 compares LOS and hospital charges between successful bougienage cases and those patients who were eligible for bougienage but instead underwent surgical retrieval. In both comparisons, charges and LOS were significantly less in the bougienage groups.

4. Discussion

In this study we observed a 94% success rate with esophageal bougienage for lodged esophageal coins and no major complications. As bougienage is an uncommon management technique, it is important to demonstrate that success and complication rates are similar among those few institutions that do practice this technique and that they parallel the success and complication rates with other management techniques. Our success rates are similar to those few studies that have previously reported their experiences with bougienage and further emphasizes that this is an effective procedure. In a study of 372 bougienage procedures compared to 248 endoscopies, Arms et al reported a success rate of 95% [2]. Four smaller studies comprising a total of 99 bougienage procedures reported success rates ranging between 85% and 100% [19,21,22,26]. This study’s 94% success rate is also comparable to the 88% to 96% success rate reported for coin removal with a Foley catheter and the 96% success rate reported for upper esophageal coin retrieval with direct laryngoscopy and forceps [2,6,18,27].

This study demonstrates that esophageal bougienage is a safe procedure for acutely ingested coins. Specifically, we observed no major complications, and to our knowledge, there have been no serious complications with esophageal bougienage reported in the literature [2,19,21–23]. Although in this study, several children underwent bougienage with unclear time frames from coin ingestion, the authors note that the criteria for bougienage as outlined by Jona et al, and similar to our institution’s guidelines, should be followed [14]. Although a short time of coin lodgement (<24 hours) does not cause significant mucosal injury in a previously healthy child, there is risk of esophageal injury or perforation with prolonged coin entrapment or in a child with prior gastro-esophageal disease or gastro-esophageal surgery [14,23]. Of note, one patient in this case series had a history of repaired pyloric stenosis and underwent bougienage. Although bougienage was successful and this patient did not require further intervention, the authors do not advocate bougienage of children with prior gastro-esophageal repair or co-morbidities. The authors do again note that children with inappropriate bougienage had a 75% success rate compared to 95% for those who met criteria.

The authors also note that given the frequency of button battery ingestions, it is imperative that 2-view radiography be used to rule out the presence of a battery. This approach will also detect multiple coins. Proper use of inclusion criteria for bougienage, namely that the ingestion has been witnessed should also prevent bougienage of a non-coin object. However, even if the child is asymptomatic, imaging should be undertaken for parental concern. In our study 48% of patients were asymptomatic upon PED presentation, and this proportion is similar to the study by Arms et al in which 41% were asymptomatic [2]. Additionally, the proportions of coin types were similar [2]. However, in our study the authors noted that a greater percentage of pennies were in the endoscopy group. Consequently, the authors surmise that in the successful bougienage group, there were a greater number of pennies present than reported, as coin type in this cohort was based on only on parental history.
Although in this study the average age of the child with a failed bougienage procedure was less than that of a child with a successful procedure, 3 children under 1 year underwent successful bougienage. Given the limited evidence, it is unclear whether children < 1 should be excluded from bougienage, but exclusion may be the more conservative approach, particularly as most ingestions by infants are also not witnessed.

Although there are serious theoretical risks of esophageal bougienage, the major risks for other coin retrieval methods are as significant, if not greater. Endoscopy is generally considered the safest surgical retrieval method, but general anesthesia has risks including hypoxia, aspiration, and malignant hyperthermia [2]. There is also growing concern that general anesthesia exposure in young children may place them at risk for subsequent neurocognitive impairment [28–30].

Fluoroscopic retrieval using a Foley catheter typically incorporates sedation and therefore presents the same anesthesia risks as those previously mentioned for surgical retrieval. Similar to bougienage, it also exposes the child to a modest dose of radiation. [31] Fluoroscopic retrieval may additionally lead to respiratory distress or esophageal perforation, and it may cause coin aspiration and airway obstruction in the patient who has not been intubated [2,32]. Intubation and direct laryngoscopy also pose substantial risks. A retrospective review of rapid sequence intubation using forceps retrieval or Foley removal reported a range of complications including dental injuries, lip lacerations, prolonged intubation, accidental extubation, prolonged paralysis, bradycardia, and hypoxia [16]. Although observation for passage of distal esophageal foreign bodies is sometimes advocated because many coins in this location do spontaneously pass, an estimated 4% of patients undergoing observation will experience complications [1,33,34].

There are minor complications with the use esophageal bougienage including gagging, discomfort, and vomiting. An additional disadvantage is repeat radiography. These should be discussed during informed consent. Intranasal midazolam before the procedure may reduce the patient who has not been intubated [2,32]. Intubation and direct laryngoscopy also pose substantial risks. A retrospective review of rapid sequence intubation using forceps retrieval or Foley removal reported a range of complications including dental injuries, lip lacerations, prolonged intubation, accidental extubation, prolonged paralysis, bradycardia, and hypoxia [16]. Although observation for passage of distal esophageal foreign bodies is sometimes advocated because many coins in this location do spontaneously pass, an estimated 4% of patients undergoing observation will experience complications [1,33,34].

Despite that faster resolution of patient outcome, it did not measure patient and parent satisfaction with informed consent. Intranasal midazolam before the procedure may reduce risk of esophageal bougienage poses risks including hypoxia, aspiration, and malignant hyperthermia [2]. There is also growing concern that general anesthesia exposure in young children may place them at risk for subsequent neurocognitive impairment [28–30].

A decision analysis comparison of all 4 management strategies for lodged esophageal coins also supports that bougienage is the most cost effective strategy [7]. Given the additional consultants, personnel, equipment, and operating and recovery room time needed for surgical retrieval, it is not surprising that bougienage is faster and less costly.

The bougienage technique may be easily and rapidly taught to clinicians. A study of 46 bougienage procedures performed by pediatric emergency physicians who underwent a 1-hour training session had a 100% success rate without complications [22]. We believe that familiarity with this procedure may lead to greater use, given the advantages of time, cost, and safety.

5. Limitations

This study has several limitations. First this project was retrospective and subjective to the drawbacks inherent with a medical record review. Data abstraction depended upon the legibility, completeness, and accuracy of information recorded and was contingent upon the interpretation and accuracy of the investigators performing abstraction. We attempted to mitigate these weaknesses through collective piloting of the data abstraction form, pre-defined variables, resolution of uncertainties in data abstraction through group consensus, and performing repeat data abstraction on 10% of the patient medical records.

Additionally, cases may have been missed due to inappropriate ICD-9 code assignments.

6. Conclusions

In conclusion, esophageal bougienage for eligible patients is a safe and highly effective procedure. It is also more time and cost efficient than endoscopic retrieval, but general anesthesia has risks including hypoxia, aspiration, and malignant hyperthermia [2]. Arms et al found a difference in LOS of almost 4 hours and a charge difference of $4200 [2]. Two smaller studies found differences in LOS as small as 6 hours, and as large as 20 hours [19,21]. A decision analysis comparison of all 4 management strategies for lodged esophageal coins also supports that bougienage is the most cost effective strategy [7]. Given the additional consultants, personnel, equipment, and operating and recovery room time needed for surgical retrieval, it is not surprising that bougienage is faster and less costly.

### Table 6

<table>
<thead>
<tr>
<th>All successful Bougienage</th>
<th>All surgical management</th>
<th>P</th>
<th>95% CI</th>
</tr>
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<tbody>
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<td>N = 136</td>
<td>N = 109</td>
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<td></td>
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<tr>
<td>Mean Age (y)</td>
<td>4.1</td>
<td>2.4</td>
<td>&lt;.001</td>
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<tr>
<td>LOS (min)</td>
<td>137</td>
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<td>-.001</td>
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<tr>
<td>Hospital charges (US$)</td>
<td>984</td>
<td>7022</td>
<td>-.001</td>
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<tr>
<td>± SD</td>
<td>476</td>
<td>54</td>
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### Table 7

<table>
<thead>
<tr>
<th>All Successful Bougienage</th>
<th>Bougienage Eligible, Surgery</th>
<th>P</th>
<th>95% CI</th>
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<td>N = 136</td>
<td>N = 29</td>
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<td></td>
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<tr>
<td>Mean Age (y)</td>
<td>4.1</td>
<td>3.4</td>
<td>0.152</td>
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<tr>
<td>Length of stay (min)</td>
<td>137</td>
<td>674</td>
<td>&lt;.001</td>
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<tr>
<td>Hospital charges (US$)</td>
<td>984</td>
<td>6630</td>
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than surgical interventions. Bougienage is an underutilized treatment modality that could be easily and successfully implemented in most Pediatric Emergency Departments. With rising healthcare costs and hospital overcrowding, esophageal bougienage offers a more economical and efficient solution to a common pediatric problem.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ajem.2014.08.007.

References