

Four Strategies for the Management of Esophageal Coins in Children

Joyce V. Soprano, MD, and Kenneth D. Mandl, MD, MPH

ABSTRACT. *Objective.* To compare clinical outcomes and costs under 4 strategies for the management of esophageal coins in children.

Methods. We developed a decision analysis model of 4 possible strategies for managing esophageal coins: 1) endoscopic removal under general anesthesia; 2) esophageal bougienage, 3) an outpatient 12- to 24-hour observation period to allow spontaneous coin passage; and 4) an inpatient observation period. Probabilities of success and complication rates for endoscopy and esophageal bougienage were obtained from published data. The probability of spontaneous coin passage was derived from chart review data at our institution. Costs were calculated from charges using a cost-to-charge ratio of .72. Hypothetical patients included in the model were those with a single esophageal coin presenting within 24 hours of ingestion, with no respiratory compromise on presentation and with no previous history of esophageal disease. Strategy-specific outcomes were overall complication rate and total cost in dollars per patient. Sensitivity analyses were performed to account for variations in the data.

Results. The esophageal bougienage strategy resulted in no complications and a total cost per patient of \$382, which represents a marginal advantage of \$2915 per patient compared with the endoscopic removal strategy. On sensitivity analysis over the range of success and complication rates of bougienage, this strategy maintained a considerable decrease in both overall complications and total cost per patient compared with all other strategies. Both outpatient and inpatient observation strategies had overall complication rates of 4.2% compared with the complication rate of 5.8% for the endoscopy strategy. The total cost per patient under these strategies was \$2439 for the outpatient and \$3141 for the inpatient strategy, representing a marginal advantage of \$858 and \$156 per patient, respectively, compared with the endoscopy strategy. Both observation strategies maintained a lower overall complication rate compared with endoscopy in the sensitivity analysis. The outpatient observation strategy maintained a marginal advantage of \$645 to \$1257 per patient compared with endoscopy; however, the inpatient observation strategy total cost per patient surpassed that of endoscopy at a spontaneous passage rate <23%.

Conclusions. Given the high success and low complication rates reported for esophageal bougienage, substantial savings in overall complications and costs would

be expected with the use of this procedure. With spontaneous passage rates >23%, either an outpatient or an inpatient observation strategy would reduce costs and complications, compared with endoscopic removal of all esophageal coins. *Pediatrics* 2000;105(1). URL: <http://www.pediatrics.org/cgi/content/full/105/1/e5>; *esophageal bougienage, endoscopy, coin, foreign body, decision analysis*.

ABBREVIATIONS. ED, emergency department; CI, confidence interval.

Coin ingestion is the most commonly ingested foreign body in children.¹⁻⁴ When in the stomach or bowel, coins pass uneventfully through the remainder of the gastrointestinal tract in most cases.^{1,2,5,6} Many ingested coins, however, become lodged in the esophagus.^{7,8} Esophageal coins in children occasionally have been associated with serious complications.^{1,7-11} Prompt removal of esophageal coins is generally recommended.

The 3 procedures commonly used to remove esophageal coins are endoscopy under general anesthesia, extraction with a Foley catheter, and esophageal bougienage. Both endoscopy^{12,13} and Foley catheter extraction¹⁴ have been reported to have complications. In the only published studies on the use of esophageal bougienage for coin removal, no complications were reported.^{15,16}

Some coins previously lodged in the esophagus will pass spontaneously to the stomach after a few hours,^{1,5,17,18} thus eliminating the need for invasive procedures to remove the coins. Developing a clinical practice guideline that involves observing patients before they undergo an invasive procedure could potentially decrease complications and costs. We built a decision tree to compare the outcomes of 4 strategies for the management of esophageal coins in children.

METHODS

Hypothetical Subjects

The hypothetical patients for whom the model was constructed are children <18 years of age who are found on radiographic evaluation to have a single coin lodged in the esophagus. In addition, patients must be at low risk of having a complicated course according to criteria we and others have previously established.^{15-17,19} They must present within 24 hours of ingestion, have no history of previous esophageal disease or surgery, and no respiratory compromise on presentation.

Decision Analysis Model

We constructed a hypothetical decision tree comprised of 4 limbs, each representing a strategy for the management of esoph-

From the Division of Emergency Medicine, Children's Hospital, Department of Pediatrics, Harvard Medical School, Boston, Massachusetts. This work was presented in part at the Pediatric Academic Societies Annual Meeting; May 3, 1998; New Orleans, LA.

Received for publication Apr 5, 1999; accepted Jul 23, 1999.

Reprint requests to (J.V.S.) Division of Emergency Medicine, Children's Hospital, 300 Longwood Ave, Boston, MA 02115. E-mail: soprano@al.tch.harvard.edu

PEDIATRICS (ISSN 0031 4005). Copyright © 2000 by the American Academy of Pediatrics.

ageal coins (Fig 1). In each limb, the patient begins with an evaluation in the emergency department (ED). In the first limb, the patient then undergoes prompt endoscopic removal of the coin under general anesthesia. After coin removal and a 1-day inpatient hospital stay, the patient is discharged.

The second limb represents the course of events if the patient undergoes a single attempt at esophageal bougienage by a well-trained pediatric emergency physician or surgeon. In this procedure, a well-lubricated bougie dilator is advanced gently from the mouth to the stomach in the upright, nonsedated patient. A post-procedure radiograph then is obtained to identify the coin location. If the coin is successfully advanced to the stomach with the bougie dilator, the patient is discharged. If the procedure is unsuccessful, the patient undergoes endoscopic removal at that time. The patient is discharged after a 1-day inpatient hospital stay.

The third and fourth limbs represent 2 strategies that include a 12- to 24-hour observation period to allow spontaneous passage of the coin to the stomach. In the first of these, the patient is observed in the ED as an outpatient. In the second, the patient is admitted to the hospital for the observation period, thus incurring the additional cost of an inpatient room for 1 day. In both strategies, if the coin spontaneously passes to the stomach during the allotted time, the patient is discharged from the hospital. If not, the patient undergoes endoscopic removal of the coin at that time, spends 1 day in the hospital after the procedure, and is discharged from the hospital.

Model Data

To determine the success and complication rates of endoscopic removal and esophageal bougienage, a Medline search was performed for all articles published since 1975 on the use of these procedures for esophageal coin removal in children. Case reports and articles describing the removal of foreign bodies other than coins were excluded, as were articles in which success and complication rates of the procedure were not reported.

The data from 6 articles on the use of endoscopy for esophageal coin removal were used.^{8,12,13,19-21} The procedure was used in a total of 362 patients and was successful (defined as coin removal or advancement to the stomach) in all cases for an overall success rate of 100% (95% confidence interval [CI]: 99.2%–100%). There were complications reported in 21 (5.8%) of these patients (95% CI: 4.6%–8.9%). These cases included 8 patients with stridor, 6 with a postoperative flare of preexisting lung disease, 2 with extended respiratory depression, 2 with postoperative fevers, 1 patient who developed laryngospasm after the endotracheal tube was dislodged, 1 who developed laryngospasm after extubation, and 1 patient who vomited and aspirated requiring an admission to the intensive care unit. Some of the patients in these studies had coins lodged in the esophagus >24 hours.

For esophageal bougienage, we reviewed the results of the only 2 previous studies in the literature.^{15,16} The procedure successfully advanced coins to the stomach in all the 77 patients in the 2 studies, for an overall success rate of 100% (95% CI: 94%–100%).

No complications of the procedure were reported in either study (95% CI: 0%–4%).

We previously measured the rate of spontaneous passage of esophageal coins to the stomach.¹⁷ We found that, for patients meeting the same criteria as the hypothetical patients in the model, an overall 28% (95% CI: 21%–41%) of esophageal coins passed spontaneously to the stomach in the 12 hours after ingestion in those patients who underwent a repeat radiographic evaluation.

Costs

Individual hospital charges were determined from billing data at our institution (Table 1). The charge for endoscopy included surgeon's fees and 60 to 90 minutes each of anesthesia, operating room, and recovery room services. Costs were derived from charges using a cost-to-charge ratio of .72 and were reported in 1997 US dollars.

Assumptions

Because endoscopy is nearly always successful for the removal or advancement of esophageal coins, we did not model a secondary branch whereby patients with failed endoscopy require surgical removal of the coin (Fig 1). Although such a procedure would be both costly and associated with potential complications, the rarity of this event would result in a minimal increase of the strategy-specific outcomes of the model. In the previous study at our institution of children with esophageal coins, there were no complications reported between arrival to the ED and either spontaneous passage of the coin or endoscopic removal.¹⁷ Furthermore, our Medline search produced no reports of stable patients who spontaneously aspirated a coin previously located in the esophagus. Therefore, we chose not to model secondary branches in which inpatients or outpatients being observed have respiratory complications related to coin aspiration.

Analysis

A baseline analysis of the model with the data that best represented each strategy was performed. Strategy-specific outcomes were overall complication rate and total cost in dollars per patient for each limb of the decision analysis model. To obtain these values, the complications and costs associated with each branch of the tree were multiplied by the probability of entering that branch. The branch results then were summed for each limb to obtain the strategy-specific outcomes. The marginal advantage of 1 strategy over another was determined based on the difference between the strategy-specific outcomes.

Sensitivity analyses were performed to account for possible variations in the data. Values were varied over the 95% CIs determined from the previous data for: 1) success rates of bougienage of 94% to 100%; 2) complication rates of bougienage of 0% to 4%; and 3) rates of spontaneous passage of coins to the stomach of 21% to 41%. The results of the sensitivity analyses were used to

Fig 1. Decision tree. The 4 limbs are shown on the far left. The shaded branch was not included in the analysis.

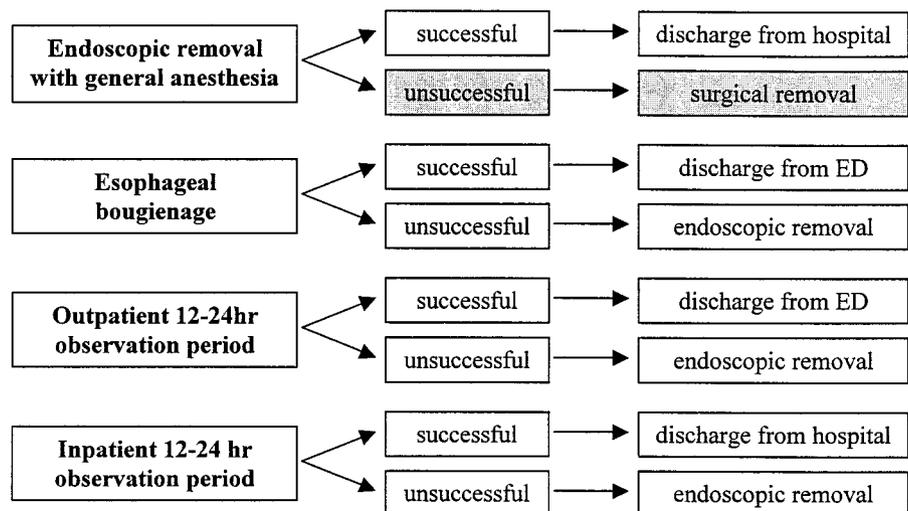


TABLE 1. Itemized Charges

Service	Charge
ED visit	\$ 320
Esophageal bougienage	\$ 211
Endoscopy under general anesthesia*	\$3284
Inpatient room per day	\$ 975

* Includes surgeon's fee \$639, operating room services \$1550, anesthesia \$470, and recovery room \$625.

determine whether variations in the data resulted in a change in the model conclusions.

RESULTS

Overall Complication Rates

The overall complication rates for each limb of the model were determined to be 5.8% for the endoscopic removal strategy, 0% for the bougienage strategy, and 4.2% for each of the observation strategies in the baseline analysis (Table 2). On sensitivity analysis, the bougienage strategy resulted in an overall complication rate as high as 4% when the procedure was 100% successful and 4.4% when the procedure was 94% successful (representing the need for endoscopy and its associated complications for the 6% of cases of failed bougienage). For the range of spontaneous coin passage rates of 21% to 41%, the overall complication rate of the observation strategies ranged from 3.4% to 4.6%. All 3 of these strategies, therefore, resulted in a decreased overall complication rate, compared with the endoscopy strategy for all feasible values in the sensitivity analyses.

Total Cost per Patient

The total cost per patient for each limb of the model in the baseline analysis was \$3297 for the endoscopic removal strategy, \$382 for the esophageal bougienage strategy, \$2439 for the outpatient observation strategy, and \$3141 for the inpatient observation strategy (Table 3). The marginal advantage of the esophageal bougienage strategy was \$2915 per patient over the endoscopic removal strategy, and \$2057 and \$2759 per patient over the outpatient and

TABLE 2. Strategy-specific Outcomes: Overall Complication Rates

Strategy	Baseline Analysis (%)	Sensitivity Analysis (%)
Endoscopic removal	5.8	—
Esophageal bougienage	0	0–4.4
Outpatient observation	4.2	3.4–4.6
Inpatient observation	4.2	3.4–4.6

TABLE 3. Strategy-specific Outcomes: Total Cost per Patient

Strategy	Baseline Analysis		Sensitivity Analysis	
	Total	Marginal Advantage*	Total	Marginal Advantage*
Endoscopic removal	\$3297	—	—	—
Esophageal bougienage	\$ 382	\$2915	\$ 382–566	\$2731–2915
Outpatient observation	\$2439	\$ 858	\$2040–2652	\$ 645–1257
Inpatient observation	\$3141	\$ 156	\$2742–3355	\$ 0–555

* Over the endoscopic removal strategy.

inpatient observation strategies, respectively. The marginal advantage of the outpatient and inpatient observation strategies was \$858 and \$156 per patient, respectively, over the endoscopic removal strategy.

Sensitivity analysis over the range of success rates of esophageal bougienage (94%–100%) resulted in a total cost per patient that ranged from \$382 to \$566 for the bougienage strategy. This corresponded to a marginal advantage of \$2731 to \$2915 per patient over the endoscopy strategy, \$1873 to \$2057 per patient over the outpatient observation strategy, and \$2575 to \$2759 per patient over the inpatient observation strategy (Table 3).

Sensitivity analysis over the range of spontaneous coin passage rates (21%–41%) resulted in a total cost per patient in the outpatient observation strategy that ranged from \$2040 to \$2652. This corresponded to a marginal advantage of \$645 to \$1257 per patient over the endoscopy strategy. For the inpatient observation strategy, the total cost per patient ranged from \$2742 to \$3355 over the range of spontaneous rates of coin passage. The marginal advantage for this strategy was as high as \$555 per patient compared with the endoscopy strategy if the spontaneous passage rate was set at 41% and was equal to that of the endoscopy strategy at a spontaneous passage rate of 23%. Below this equalization threshold, total cost per patient exceeded that of the endoscopy strategy (Fig 2).

DISCUSSION

Of the 4 strategies for the management of esophageal coins in children included in our model, the esophageal bougienage strategy resulted in the lowest overall complication rate and total cost per patient. The outpatient observation strategy resulted in a more modest reduction in overall complication rate and total cost per patient, compared with the endoscopic removal of all esophageal coins. The inpatient observation strategy, although resulting in a decrease in overall complication rate compared with the endoscopic removal strategy, resulted in only a small reduction in total cost per patient at higher rates of spontaneous coin passage and exceeded the total cost per patient of the endoscopy strategy at the lower rates of spontaneous coin passage.

In a decision analysis by Conners,²² endoscopic removal, Foley catheter extraction, and esophageal bougienage for pediatric esophageal coin removal were compared. A significant reduction in costs was reported for both Foley catheter extraction and bougienage, compared with endoscopy; strategies involving observation periods to allow spontaneous

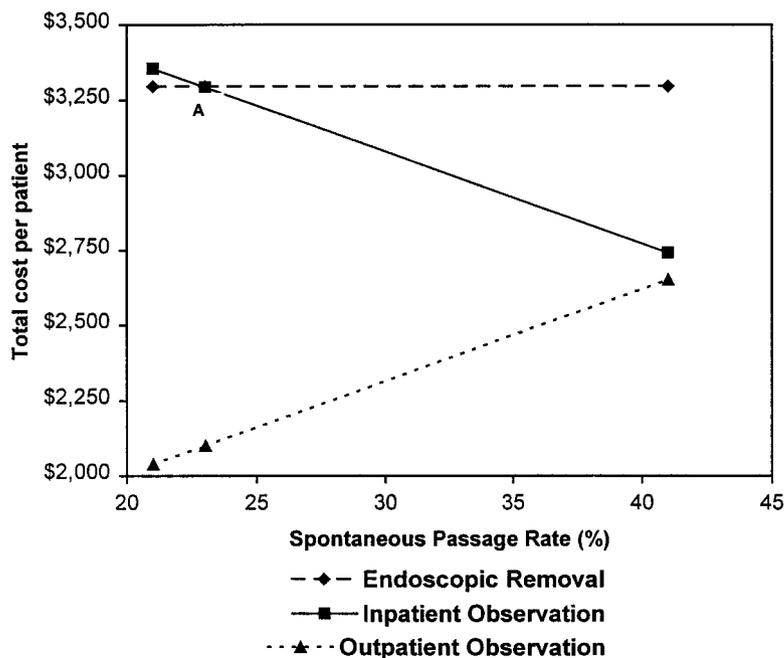


Fig 2. A sensitivity analysis was performed by varying the values for the spontaneous passage rate from 21% to 41% and reanalyzing the model. The resultant total cost per patient of the endoscopy strategy and the outpatient and inpatient observation strategies are shown. The total cost of the outpatient strategy lies below that of the other 2 strategies at all rates of spontaneous passage tested. Point A, the equalization threshold, is the point at which the inpatient observation and endoscopy strategies result in the same total cost per patient. This occurs at a spontaneous passage rate of 23%.

coin passage were not reported. In a retrospective review of the management of esophageal coins in children at his institution, Kelley et al²⁰ also found that both Foley catheter extraction and bougienage were significantly less expensive than endoscopy. Neither study demonstrated a significant difference in the complication rates of the different strategies.

Our report is the first decision analysis that has included strategies with an observation period to allow spontaneous passage of esophageal coins before an invasive procedure to remove the coins. Many previous studies have described the spontaneous passage of esophageal coins in children.^{5,7,8,17,21,23} In a previous study at our institution, we found that, in patients meeting the same criteria as the hypothetical patients in the decision analysis model, 28% of esophageal coins passed spontaneously in the 12 hours after ingestion.¹⁷

This decision analysis shows that strategies including such observation periods would indeed decrease overall complication rates, compared with the prompt endoscopic removal of all coins. In addition, if the patient can be observed in the ED as an outpatient to await spontaneous passage, costs are significantly lower than those of the endoscopy strategy. If the patient is observed as an inpatient the cost savings become minimal, but there is still an important decrease in the overall complication rate, compared with the endoscopic removal of all coins.

Esophageal bougienage resulted in a far greater reduction in total cost per patient than either of the observation strategies. This procedure, however, although used routinely in some institutions, has not achieved the universal acceptance that endoscopy has for the removal of esophageal coins. The results of this decision analysis arise from the extremely high success and low complication rates for bougienage, reported in the literature. Based on the CI calculated from these data, however, the complication rate may be as high as 4%. On the sensitivity analysis

of the model, in which the complication rate was varied over this CI, the esophageal bougienage strategy still resulted in a lower overall complication rate, compared with the endoscopy strategy. Our results should, however, be examined cautiously until additional large studies on the safety of bougienage for this indication are reported.

We have shown previously that patients who do not meet the criteria for this decision analysis (single coin lodged in the esophagus for <24 hours, no history of previous esophageal disease or surgery, and no respiratory compromise on presentation to the ED) are unlikely to have spontaneous passage of an esophageal coin.¹⁷ In addition, the safety and efficacy of esophageal bougienage has only been described for patients meeting these criteria.^{15,16} Therefore, endoscopy remains the procedure of choice for patients not meeting these criteria.

The studies on the use of endoscopy for coin removal did not report solely on the use of this procedure in patients who would have met our criteria for the decision analysis, because some patients had coins lodged for >24 hours. The true complication rate of endoscopy for our study population, therefore, may be slightly lower, thus all strategies would be expected to have a lower overall complication rate proportional to the number of endoscopies performed in that strategy. The final ordering of the branches, however, would not be expected to change.

Complications that may occur postoperatively after endoscopic coin removal were not included in the model. Although these are extremely rare, we would expect them to increase the overall complication rate and total cost per patient of each strategy in an amount proportional to the number of endoscopies performed in that strategy. Including the postoperative complications of endoscopy, therefore, would not be expected to change our final conclusion.

CONCLUSION

Given the high success rate, low complication rate, and low cost of esophageal bougienage, the widespread use of this procedure for appropriate patients would result in significant reductions in complications and costs, compared with the other strategies for the management of esophageal coins. A clinical practice guideline that includes an outpatient observation period to allow coins to pass spontaneously to the stomach will result in a reduction in overall complications and costs, compared with the endoscopic removal of all esophageal coins. Because of the high cost of hospital admissions, however, a clinical practice guideline that includes an inpatient observation period may not result in a reduction in costs but would still decrease overall complications.

REFERENCES

1. Spitz L. Management of ingested foreign bodies in childhood. *Br Med J*. 1971;4:469-472
2. Suita S, Ohgami H, Nagasaki A, Yakabe S. Management of pediatric patients who have swallowed foreign objects. *Am Surg*. 1989;55:585-590
3. Nandi P, Ong GB. Foreign body in the oesophagus: review of 2394 cases. *Br J Surg*. 1978;65:5-9
4. Binder L, Anderson WA. Pediatric gastrointestinal foreign body ingestion. *Ann Emerg Med*. 1984;13:112-117
5. Stringer MD, Capps SN. Rationalising the management of swallowed coins in children. *Br Med J*. 1991;302:1321-1322
6. Jones PG. Swallowed foreign bodies in childhood. *Med J Aust*. 1963;50:236-239
7. Caravati EM, Bennett DL, McElwee NE. Pediatric coin ingestions: a prospective study on the utility of routine roentgenograms. *Am J Dis Child*. 1989;143:549-551
8. Hodge D, Tecklenburg F, Fleisher G. Coin ingestion: does every child need a radiograph? *Ann Emerg Med*. 1985;14:443-446
9. Nahman B, Meuller C. Asymptomatic esophageal perforation by a coin in a child. *Ann Emerg Med*. 1984;13:627-629
10. Obiako MN. Tracheoesophageal fistula: a complication of foreign body. *Ann Otol Rhinol Laryngol*. 1982;91:325-327
11. Vella EE, Booth PJ. Foreign body in the oesophagus. *Br Med J*. 1965;2:1042
12. Berggreen PJ, Harrison ME, Sanowski RA, Ingebo K, Noland B, Zierer S. Techniques and complications of esophageal foreign body extraction in children and adults. *Gastrointest Endosc*. 1993;39:626-630
13. Hawkins DB. Removal of blunt foreign bodies from the esophagus. *Ann Otol Rhinol Laryngol*. 1990;99:935-940
14. Schunk JE, Harrison M, Corneli HM, Nixon GW. Fluoroscopic Foley catheter removal of esophageal foreign bodies in children: experience with 415 episodes. *Pediatrics*. 1994;94:709-714
15. Bonadio WA, Jona JZ, Glicklich M, Cohen R. Esophageal bougienage technique for coin ingestion in children. *J Pediatr Surg*. 1988;23:917-918
16. Emslander HC, Bonadio W, Klatzo M. Efficacy of esophageal bougienage by emergency physicians in pediatric coin ingestion. *Ann Emerg Med*. 1996;27:726-729
17. Soprano JV, Mandl, KD, Fleisher, GR. The spontaneous passage of esophageal coins in children. *Arch Pediatr Adolesc Med*. 1996;153:1073-1076
18. Chaikhouni A, Kratz JM, Crawford FA. Foreign bodies of the esophagus. *Am Surg*. 1985;51:173-179
19. Bonadio WA, Emslander H, Milner D, Johnson L. Esophageal mucosal changes in children with an acutely ingested coin lodged in the esophagus. *Pediatr Emerg Care*. 1994;10:333-334
20. Kelley JE, Leech MH, Carr MG. A safe and cost-effective protocol for the management of esophageal coins in children. *J Pediatr Surg*. 1993;28:898-900
21. Conners GP, Chamberlain JM, Ochenschlager DW. Symptoms and spontaneous passage of esophageal coins. *Arch Pediatr Adolesc Med*. 1995;149:36-39
22. Conners GP. A literature-based comparison of three methods of pediatric esophageal coin removal. *Pediatr Emerg Care*. 1997;13:154-157
23. Schunk JE, Corneli H, Bolte R. Pediatric coin ingestion: a prospective study of coin location and symptoms. *Am J Dis Child*. 1989;143:546-548

Four Strategies for the Management of Esophageal Coins in Children

Joyce V. Soprano and Kenneth D. Mandl

Pediatrics 2000;105:e5

DOI: 10.1542/peds.105.1.e5

Updated Information & Services

including high resolution figures, can be found at:
<http://pediatrics.aappublications.org/content/105/1/e5>

References

This article cites 23 articles, 4 of which you can access for free at:
<http://pediatrics.aappublications.org/content/105/1/e5#BIBL>

Subspecialty Collections

This article, along with others on similar topics, appears in the following collection(s):

Correction

<http://www.aappublications.org/cgi/collection/correction>

Permissions & Licensing

Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:

<http://www.aappublications.org/site/misc/Permissions.xhtml>

Reprints

Information about ordering reprints can be found online:

<http://www.aappublications.org/site/misc/reprints.xhtml>

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®



PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Four Strategies for the Management of Esophageal Coins in Children

Joyce V. Soprano and Kenneth D. Mandl

Pediatrics 2000;105:e5

DOI: 10.1542/peds.105.1.e5

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/105/1/e5>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2000 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

