Retrospective Cohort Study on the Optimal Timing of Orogastric Tube/Nasogastric Tube Insertion in Infants With Pyloric Stenosis

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Background: Hypertrophic pyloric stenosis in infants can cause a buildup of gastric contents. Orogastric tubes (OGTs) or nasogastric tubes (NGTs) are often placed in patients with pyloric stenosis before surgical management to prevent aspiration. However, exacerbation of gastric losses may lead to electrolyte abnormalities that can delay surgery, and placement has been associated with increased risk of postoperative emesis. Currently, there are no evidence-based guidelines regarding OGT/NGT placement in these patients. This study examines whether OGT/NGT placement before arrival in the operating room was associated with a longer time to readiness for surgery as defined by normalization of electrolytes. Secondary outcomes included time from surgery to discharge and ability to tolerate feeds by 6 hours postoperatively in patients with and without early OGT/NGT placement.

Methods: In this multicenter retrospective cohort study, data were extracted from the medical records of 481 patients who underwent pyloromyotomy for infantile hypertrophic pyloric stenosis from March 2013 to June 2016. Multivariable linear regression and Cox proportional hazard models were constructed to evaluate the association between placement of an OGT/NGT at the time of admission with increased time to readiness for surgery (defined as the time from admission to the first set of normalized laboratory values) and increased time from surgery to discharge. Multivariable logistic regression was used to evaluate the association between early OGT/NGT placement and the ability to tolerate oral intake at 6 hours postsurgery. Analyses were adjusted for site differences.

Results: Among patients admitted with electrolyte abnormalities, those with an OGT/NGT placed on presentation required more time until their serum electrolytes were at acceptable levels for surgery by regression analysis (19.2 hours difference; 95% confidence interval, 10.05–28.41; P < .001), after adjusting for site. Overall, patients who had OGTs/NGTs placed before presentation in the operating room had a longer length of stay from surgery to discharge than those without (38.8 hours difference; 95% confidence interval, 25.35–52.31; P < .001), after adjusting for site. OGT/NGT placement before surgery was not associated with failure to tolerate oral intake within 6 hours of surgery after adjusting for site, corrected gestational age, and baseline serum electrolytes.

Conclusions: OGT/NGT placement on admission for pyloric stenosis is associated with a longer time to electrolyte correction in infants with abnormal laboratory values on presentation and, subsequently, a longer time until they are ready for surgery. It is also associated with longer postoperative hospital stay but not an increased risk of feeding intolerance within 6 hours of surgical repair. (Anesth Analg 2019;129:1079–86)

Key Points

• Question: Is placement of an orogastric or a nasogastric tube before arrival in the operating room in infants with hypertrophic pyloric stenosis associated with prolonged electrolyte abnormalities, delay to surgery and discharge, and prolonged postoperative feeding intolerance?

• Findings: Early placement of these tubes is associated with prolongation of electrolyte abnormalities in infants presenting with abnormal laboratory values and increased time from surgery to discharge in all patients, but it is not associated with failure to tolerate oral intake within 6 hours of surgery after adjusting for site, corrected gestational age, and baseline serum electrolytes.

• Meaning: Placement of orogastric or nasogastric tubes in infants awaiting surgery for pyloric stenosis may lead to a prolonged hospital course, and alternative means for gastric emptying preoperatively should be considered.
Infantile hypertrophic pyloric stenosis causes partial or complete gastric outlet obstruction, often leading to accumulation of gastric contents within the stomach. Historically, these patients have presented to the operating room (OR) with an orogastric tube (OGT) or a nasogastric tube (NGT) that was placed in the emergency department or inpatient setting for gastric decompression. However, gastric emptying immediately before induction of anesthesia and improved anesthetic and surgical management have virtually eliminated perioperative pulmonary complications. Recently, there has been a shift in practice at some institutions, and an increasing number of infants are presenting to the OR without an OGT/NGT in place.

The risks and benefits of OGT/NGT placement early in the admission must be weighed. Gastric suctioning may worsen existing alkalemia and can therefore contribute to postoperative apnea and difficulty with safe extubation.\(^1\) Electrolyte abnormalities exacerbated by gastric losses can delay medical stabilization and the necessary, definitive surgery. Furthermore, preoperative placement of an OGT/NGT does not guarantee reduction in gastric volume. In a 1997 study, volumes aspirated just before induction of anesthesia, after removal of an in situ NGT, averaged 4.8 ± 4.3 mL/kg, with 83% having >1.25 mL/kg.\(^2\) The volume of residual gastric fluid was independent of barium use, preoperative NGT placement, and fasting time. However, the effectiveness of passing a large-bore OGT just before induction of anesthesia was effective in removing all residual volume in >90% of patients.\(^3\) OGT/NGT placement may also be associated with increased postoperative emesis, thereby prolonging time to full feeds and delaying discharge to home.\(^4\)

Currently, no clinical guidelines address the timing of gastric tube placement in infants with pyloric stenosis. The primary aim of this study was to determine whether having an OGT/NGT placed at the time of admission is associated with an increased time to readiness for surgery in infants presenting with pyloric stenosis. The secondary aim was to determine whether having an OGT/NGT placed at the time of admission was associated with oral intake intolerance 6 hours postoperatively or prolonged time from surgery to discharge.

METHODS

Patient Population and Variable Definitions

In this 4-center retrospective cohort study, we identified the medical records of patients who underwent corrective surgery for pyloric stenosis from March 2013 to June 2016. Institutional Review Board approval was obtained before the start of the study at all 4 centers, and written informed consent was waived. Eligible patients were identified by billing codes. Patients with incomplete records or who ultimately did not undergo surgical repair were excluded. Baseline information collected on each patient included gender, postgestational age at the time of admission, weight on admission, and number of days of symptoms before admission, as noted in the medical record. Additional covariates that were collected included baseline laboratory values, defined as the first set of serum electrolytes available for that admission, including time drawn; the final set of serum electrolytes and time drawn; and whether the patient had an OGT/NGT placed before arriving in the OR, the main predictor in our study. The times for admission, patient arrival to the OR, and discharge were also recorded. Definitions of these times were standardized across all 4 institutions.

Outcome Definitions

For this study, the primary outcome was time to readiness for surgery. To avoid confounding from OR scheduling, surgeon availability, and other external factors, we defined time to readiness as the time from presentation to the first set of normalized laboratory values (sodium, >130 mEq/L; potassium, >3 mEq/L; chloride, >90 mEq/L; and bicarbonate, <30 mEq/L). Time from surgery to discharge was defined as anesthesia start time to time of discharge from the hospital. Finally, intolerance of oral intake at 6 hours postprocedure was defined as the inability to tolerate full feeds, requiring decreased intake or resumption of nil per os status. In addition, we performed subanalyses where the cohort was stratified by whether their serum electrolytes were normal on admission (thus meeting “readiness for surgery” criteria) for the secondary outcomes. If patients had serum electrolyte abnormalities requiring fluid resuscitation, they were deemed not ready for surgery, whereas if their serum electrolytes were within normal ranges, they were considered ready. The evaluation of the primary outcome was limited to the subgroup that had abnormal serum electrolytes on presentation. Severity of electrolyte abnormality was defined as the absolute value deviation from the normal value.

Perioperative Management

At all institutions, infants were given normal saline boluses at 20 mL/kg for volume resuscitation as needed. Five percent dextrose in half-normal saline, with or without potassium supplementation depending on the infant’s ability to produce urine, was given as maintenance fluid. Preoperative 4-quadrant suctioning was performed before rapid sequence intravenous induction and placement of endotracheal tube for all patients. Type of intraoperative maintenance fluid, paralytic agent, and use of acetaminophen and opioids varied from institution to institution, as did discharge criteria and postoperative care of the patient. All 4 institutions required that the patient be able to tolerate 2 full consecutive feeds before discharge; however, the required nil per os time after surgery was variable. Details of the perioperative management at each institution are given in Supplemental Digital Content 1, Table 1, http://links.lww.com/AA/C580.

Statistical Analysis

Means and standard deviations were calculated for baseline patient characteristics data that were approximately normally distributed. Differences between the OGT/NGT and non-OGT/NGT groups were tested using the t test, whereas between-site comparisons were assessed using 1-way analysis of variance. Medians and quartiles were calculated for data that were skewed, and Wilcoxon rank sum test was used to test for differences. For categorical data, counts and...
proportions were tabulated, and differences were assessed using the $\chi^2$ test.

Next, multivariable linear regression models were constructed to evaluate whether OGT/NGT placement before the OR was associated with increased time to readiness for surgery or increased length of stay (LOS) from surgery to discharge. All analyses were adjusted for site due to known practice variations. Additional covariates considered included gender, corrected gestational age on admission, age in days from birthdate, number of days of symptoms, weight, and severity of serum electrolyte abnormalities. We ran complete case analyses for our multivariable models of interest because including variables with substantial missing data (corrected gestational age and number of days of symptoms) could drastically reduce our power. Therefore, these variables were omitted in our final models. Three models were considered: 1 adjusting for site only; a second adjusting for site and baseline abnormalities; and a third adjusting for site, age on admission, gender, weight, and severity of serum electrolyte abnormalities. Linear regression model assumptions were checked using residual plots and scatter plots of the data. As a sensitivity analysis, Cox proportional hazard models were constructed to illustrate the effect of having an OGT/NGT placed on admission while controlling for site differences. The proportional hazards assumption was checked for the Cox models using the cox.zph function in R. These results were not significant.

Multivariable logistic regression was used to evaluate the association between OGT/NGT placement and the ability to tolerate oral intake at 6 hours postoperatively while adjusting for site. The multiple logistic regression analysis was also repeated while controlling for site, baseline serum electrolyte abnormalities and for site, baseline serum electrolyte abnormalities, and corrected gestational age. Hosmer–Lemeshow tests were used to assess goodness of fit in the logistic regression models and were not significant.

The variance inflation factor was calculated for all logistic and linear regression models to evaluate for multicollinearity. The value for all variance inflation factors was <5. All statistical analysis was performed in R (version 3.4.3; R Foundation for Statistical Computing, Vienna, Austria) using the lme() function for linear regression models, glm() function for logistic regression models, the “survival” package (version 2.41–3) and surv() and coxph() functions for survival analysis, and the “survminer” package (version 0.4.1) and “ggplot2” (version 2.2.1) for graphical visualization of survival curves. An $\alpha$ level of .05 was used, and 2-sided $P$ values were reported. We used Bonferroni correction to adjust for multiple hypothesis testing for these 3 different outcomes where $P$ values <.017 were considered statistically significant. This article adheres to the applicable Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

**Sample Size**

Given our resources/inclusion criteria, we were able to collect data on 145 patients with electrolyte imbalances (57 with OGT/NGT placed, 88 without OGT/NGT). With this sample size, we had 80% power to detect an effect size of 0.55 between groups (2-sample $t$ test) for an adjusted significance criterion of .017. A previous study of infants with pyloric stenosis$^3$ found an effect size difference between OGT/NGT groups in LOS of 0.57 and another outcome (vomiting after surgery) effect size of 0.60. Although our study is slightly different, we felt that we were adequately powered to detect similar levels of effect sizes previously reported in the literature with comparable patients and procedures.

**RESULTS**

A total of 496 patient records were reviewed, and 15 patients were excluded. Therefore, data from 481 patients were analyzed. A flow diagram of the distribution of patients between treatment groups is shown in Figure 1. There were 142 patients who had OGT/NGTs placed before arrival in the OR, while 339 patients did not. There were 336 patients admitted with normal serum electrolytes who were deemed ready for surgery at the time of admission, while 145 had abnormal laboratory values and required time for fluid resuscitation before surgery. There were no significant differences in baseline characteristics of gender, age on admission, weight on admission, and number of days of symptoms between the groups with and without an OGT/NGT placed at the time of admission. There was no evidence of clinically significant differences in the serum laboratory values between groups (Table 1).

There was no evidence for a clinically significant difference in most baseline patient characteristics between sites (Supplemental Digital Content 2, Table 2, http://links.lww.com/AA/C581). However, we noted a significant difference in the practice of placing OGTs/NGTs on admission between

![Figure 1. STROBE flow diagram for study population. NGT indicates nasogastric tube; OGT, orogastric tube; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.](http://links.lww.com/AA/C581)
surgery had statistically significant increased LOS by an additional 39 hours, when compared to patients without a preoperative OGT/NGT (95% CI, 25.35–52.31; \( P < .001 \)) after controlling for site. A Cox proportional hazards model constructed to assess the effect of OGT/NGT placement on admission on the LOS after surgery, while controlling for site for the full cohort, was also statistically significant (\( P < .001 \); Figure 3).

OGT/NGT placement remained a statistically significant variable when the regression was applied in the subgroup of patients who had normal laboratory values on admission, prolonging postsurgical time to discharge by an average of 43 hours after controlling for site (95% CI, 27.23–58.55; \( P < .001 \)) in patients who had an OGT/NGT placed on admission versus those who did not (Table 2). Among patients who were admitted with serum electrolyte abnormalities requiring time for correction, the difference in time from OR to discharge was not statistically significant after applying Bonferroni correction in the site-adjusted model.

Similarly, OGT/NGT placement was a statistically significant variable in the full cohort and in the group that was ready for surgery at the time of admission, but it was not statistically significant in the group that had serum electrolyte abnormalities after adjusting for site, gender, severity of baseline serum electrolytes, and weight and age on admission (Table 2). Similar results were observed when only site and baseline serum electrolyte abnormalities were adjusted for.

### Secondary Outcome 2: Ability to Tolerate Oral Intake Within 6 Hours After Surgery

Overall, those who had an OGT/NGT placed on arrival or early in their preoperative course were more likely to be intolerant of oral intake at 6 hours postoperatively, compared to those without an OGT/NGT placed before arrival in the OR (odds ratio, 3.26; 95% CI, 1.29–8.16; \( P = .012 \)) after adjusting for site (Table 3). This effect seemed more pronounced in the subgroup that was not ready for surgery, after controlling for site, at the time of admission (odds ratio, 6.16; 95% CI, 1.55–25.00; \( P = .009 \)). However, after adjusting for site, in the group that was ready for surgery at the time of admission, we did not find evidence for a difference in the ability to tolerate oral intake at 6 hours postoperatively.

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### Table 1. Baseline Characteristics by Treatment Group

<table>
<thead>
<tr>
<th></th>
<th>NGT (n = 142)</th>
<th>No NGT (n = 339)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males, n (%)</td>
<td>122 (85.9)</td>
<td>284 (83.8)</td>
<td>.348</td>
</tr>
<tr>
<td>Ready for OR at the time of admission, n (%)</td>
<td>85 (60.0)</td>
<td>249 (74.0)</td>
<td>.003</td>
</tr>
<tr>
<td>Age on admission in days, median (quartiles)</td>
<td>32 (25–42)</td>
<td>32 (26–44)</td>
<td>.454</td>
</tr>
<tr>
<td>Postconceptional age on admission in weeks, mean (SD)</td>
<td>43.4 (2.4)</td>
<td>43.4 (2.6)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Weight on admission in kg, mean (SD)</td>
<td>3.89 (0.7)</td>
<td>3.96 (0.7)</td>
<td>.318</td>
</tr>
<tr>
<td>No. days of symptoms, median (quartiles)</td>
<td>6 (3–11)</td>
<td>5 (3–8)</td>
<td>.117</td>
</tr>
<tr>
<td>No. laboratory draws needed before normalization, mean (SD)</td>
<td>1.8 (1.5)</td>
<td>1.4 (0.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Hours from the first normal electrolytes to surgery, median (quartiles)</td>
<td>10.7 (5.3–18.1)</td>
<td>13.8 (7.4–21.4)</td>
<td>.007</td>
</tr>
<tr>
<td>Baseline laboratory values, mEq/L, mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum sodium</td>
<td>137.4 (2.9)</td>
<td>138.7 (2.7)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Serum potassium</td>
<td>4.6 (0.9)</td>
<td>4.6 (0.8)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Serum chloride</td>
<td>97.4 (13.5)</td>
<td>99.7 (7.1)</td>
<td>.015</td>
</tr>
<tr>
<td>Serum bicarbonate</td>
<td>28.7 (5.3)</td>
<td>28.7 (5.0)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

**Abbreviations:** NGT, nasogastric tube; OR, operating room; SD, standard deviation.
Figure 2. Cox proportional hazards model of assessing the effect of OGT/NGT placement on number of hours before normalization of serum electrolyte levels in infants admitted with pyloric stenosis and abnormal laboratory values after adjusting for site differences (log-rank $P = .001$). Light-shaded areas represent 95% confidence interval of the corresponding curve. Darker-shaded area represents the overlap in 95% confidence intervals. NGT indicates nasogastric tube; OGT, orogastric tube; OR, operating room.

Figure 3. Cox proportional hazards model of assessing the effect of OGT/NGT placement on number of hours from surgery until discharge in infants admitted with pyloric stenosis after adjusting for site differences (log-rank $P < .001$). Light-shaded areas represent 95% confidence interval of the corresponding curve. Darker-shaded area represents the overlap in 95% confidence intervals. NGT indicates nasogastric tube; OGT, orogastric tube.
in patients who had an OGT/NGT placed early during their hospital course (odds ratio, 1.82; 95% CI, 0.53–6.48; \( P = .35 \)).

We found similar odds ratios in the model adjusting for site and baseline serum electrolytes (Table 3). However, in the model including site, baseline serum electrolytes, gender, weight, and age on admission, the association between OGT/NGT placement and oral intake intolerance 6 hours after surgery was not statistically significant in the subgroup of infants admitted with abnormal laboratory values after Bonferroni correction.

**DISCUSSION**

Pyloric stenosis is a common condition requiring surgical intervention in infants, with an incidence of 1–5 per 1000 infants. Although decreasing rates have been noted over the past several decades, complications such as aspiration remain a significant concern. Salivary and gastric secretions fill the stomach, with rates as high as 1 mL/kg/h for saliva and 0.6 mL/kg/h for gastric secretions. Even with appropriate fasting, the risk of aspiration on induction of anesthesia exists. Therefore, gastric emptying in these infants before induction of anesthesia is paramount, whereas the timing of when this should occur is less clear.

Among the patients in our study who presented with electrolyte abnormalities, the placement of an OGT/NGT before the OR was associated with significantly longer times to normalization of serum electrolytes when compared to those without a preoperative OGT/NGT placed by linear regression. Other secondary outcomes examined were whether OGT/NGT placement on admission was associated with increased times from surgery until discharge or to intolerance of postoperative oral intake. We found that across the entire cohort, placement of an OGT/NGT on admission was
associated with increased time to discharge after accounting for site only and site, baseline serum electrolyte abnormalities, gender, and weight and age on admission. This effect was the greatest in the subgroup of infants admitted with normal serum electrolytes. In the group of infants admitted with abnormal electrolytes, this effect was still observed but not statistically significant after applying Bonferroni correction in all of the models tested.

The surgery to discharge times for the group that had normal laboratory values on admission were, on average, shorter than the group with abnormal laboratory values on admission. In this study, we observed that within the group that was ready for surgery on admission, there was a larger difference in time from surgery until discharge between the OGT/NGT and no OGT/NGT groups in contrast to less of a difference in surgery to discharge times between the OGT/NGT and no OGT/NGT patients admitted with abnormal laboratory values. While this cannot necessarily be generalized to other patient populations, it may be possible that in our patients, OGT/NGT placement either has no effect or has a smaller effect in the subgroup of patients who had electrolyte abnormalities on admission, which we were not powered to detect. It is also possible that this subgroup was still more unwell after surgery was completed and thus required a longer time to be ready for discharge, masking some of the effect of OGT/NGT placement. A study with more subjects in the not ready group would be needed to confirm this pattern.

Postoperative complications associated with pyloromyotomy include emesis, delayed feeding, and prolonged hospital LOS, with emesis rates as high as 90%. The use of an OGT/NGT has been implicated in the past, although a more recent study did not find preoperative NGT placement for pyloromyotomy to be associated with increased postoperative emesis or prolonged LOS. In our study, there was an association between OGT/NGT placement and increased odds of oral intake intolerance at 6 hours postsurgery in the models that controlled for site only and for site and baseline serum electrolyte abnormalities. However, OGT/NGT placement on admission was not associated with increased odds of oral intake intolerance at 6 hours postsurgery after adjusting corrected gestational age, in addition to site and degree of baseline serum electrolyte abnormality. We believe that this discrepancy may be due to the decreased power to detect a difference because the corrected gestational age was not available in a number of patient records, and those patients were not included in the analysis. Initially, we postulated that the increased postoperative stay could be due to intolerance of oral intake. Other confounding factors not collected in this study could explain the increased surgery to discharge time in the group with OGT/NGT placement on admission in infants admitted with normal serum electrolytes.

While aspiration of gastric contents during induction and intubation is a valid concern, alternative practices to preoperative OGT/NGT exist. Awake intubations are currently uncommon, with higher rates of failed intubation, bradycardia, hypoxemia, and aspiration. Classic rapid sequence induction of anesthesia can be utilized but is associated with a 5% incidence of severe hypoxemia. Modified rapid sequence induction (eliminating cricoid pressure and using low-pressure manual ventilation) has also been used, with lower rates of hypoxemia.

The theoretical risk of passive regurgitation and aspiration exists, but in practice, the rates are low. In 2013, a prospective survey of 11 pediatric centers in the United Kingdom found a rate of 0.02%, while a US study found a rate of 0.04%. Furthermore, bedside ultrasound of the antrum may also be used to estimate gastric volume and guide suctioning immediately before induction of anesthesia, although one must be skilled in this imaging modality and optimally position the patient (right lateral decubitus) during scanning to achieve appropriate correlation with objectively measured volumes.

Limitations

One limitation identified in this study was the relative imbalance of patients who had OGTs/NGTs placed on admission between sites. There was no evidence for a clinically significant difference in baseline patient characteristics among the 4 sites, so we do not believe that patients at 1 institution were more ill on presentation relative to the others. In addition, this scenario actually improved the overall balance between the number of patients who did and did not have OGTs/NGTs on admission, relative to their severity of illness. To account for differences in practice, site was included as a covariate in all of the analyses performed. In addition, the inclusion of 4 different sites contributes to the generalizability of our study.

Another limitation in this study was our inability to include all variables in the multivariable adjusted model. The data for corrected gestational age and number of days of symptoms were available in a limited number of patient records. Thus, the lack of evidence for a difference among the patients with and without OGTs/NGTs, in the models that included this as a variable, may be due to lack of power. Although we have adjusted for the most pertinent potential confounders, a follow-up study may be needed to definitively confirm our findings, given the missing data limitation and potential confounders we did not adjust for.

Perceived readiness for surgery based on specific laboratory cutoffs can vary across institutions. For this multisite study, we based readiness on historical cutoff values of sodium >130 mEq/L, potassium >3 mEq/L, chloride >90 mEq/L, and bicarbonate <30 mEq/L. However, we acknowledge that the current trend is to allow for complete normalization (based on each laboratory’s reference value range), with complete normalization of chloride an important indicator of adequate resuscitation. The volume of gastric fluids removed was too inconsistently recorded to be analyzed, so it was left out of the analysis.

Two other limitations of this study include its retrospective nature and its inherent systemic biases. To minimize potential bias, we used 2 different methods of statistical analysis. Multiple linear regression was initially chosen for the ease of interpreting the β coefficients for the difference in terms of time. Cox modeling was a means of providing a visual model while adjusting for site. We find it reassuring that both methods arrived at the same conclusions. A larger, prospective randomized controlled trial should be performed to confirm these findings.
CONCLUSIONS
In this study, we found that the placement of an OGT/NGT before surgery was associated with a clinically and statistically significant increased time to readiness for surgery in patients with electrolyte abnormalities on initial evaluation, increased time to discharge after surgery, but not an increased likelihood of oral intake intolerance at 6 hours postprocedure. OGT/NGT placement before arrival in the OR also delayed serum electrolyte normalization. A large-scale prospective randomized controlled trial is needed to confirm these findings.

DISCLOSURES
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Name: Marc Iravani, MD.
Contribution: This author helped conceptualize the idea for the study and write and edit the manuscript.

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REFERENCES