Optimal Depth for Nasopharyngeal Temperature Probe Positioning

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BACKGROUND: The nasopharynx is considered 1 of the 4 generally reliable core temperature measurement sites. But curiously, there is no consensus on how far past the nares to insert the probe. Insertion depth is likely to influence the accuracy of nasopharyngeal temperature measurements because probes near the nares will be cooled by ambient air; similarly, probes inserted too far may approach the airway and be cooled by ventilation gases. We thus determined the range of nasopharyngeal probe insertion depths that best approximate reference core temperature measured in the distal esophagus.

METHODS: In 36 adults undergoing noncardiac surgery with endotracheal intubation, we inserted a nasopharyngeal thermometer 20 cm past the nares and an esophageal temperature probe 40 cm from the incisors. The nasopharyngeal probe was withdrawn sequentially 2 cm at a time at 5-minute intervals. Pairs of nasopharyngeal and reference distal esophageal temperatures were then compared and summarized by Bland and Altman methods.

RESULTS: All nasopharyngeal probe insertion depths between 10 and 20 cm past the nares provided temperatures similar to reference distal esophageal temperatures. At those depths, the bias was typically approximately −0.1°C, with SD of approximately ±0.15°C; the limits of agreement thus were easily within our a priori specified clinically acceptable range of −0.5°C and 0.5°C.

CONCLUSIONS: Any nasopharyngeal probe insertion depth between 10 and 20 cm well represents core temperature in adults having noncardiac surgery. (Anesth Analg 2016;122:1434–8)

General anesthesia impairs central thermoregulatory control.[1] Impaired thermoregulation, combined with a cool operating environment, makes most unwarmed surgical patients hypothermic.[2] Mild perioperative hypothermia causes coagulopathy,[3] increases the risk of wound infection,[4] and prolongs drug action.[5] Consequently, it is now standard-of-care to both monitor core temperature and maintain intraoperative normothermia.

There are 4 monitoring sites that generally well represent core body temperature: pulmonary artery, distal esophagus, tympanic membrane (directly measured with a contact thermometer), and nasopharynx.[1] The nasopharynx is the part of the pharynx that lies superior to the soft palate. Anteriorly, it opens into the nasal cavities through the choanae; inferiorly, it communicates with the oropharynx through the pharyngeal isthmus. Temperature in the nasopharynx is thought to accurately reflect core temperature because of its proximity to the brain.[6,7] The nasopharynx is among the most common temperature monitoring sites,[8] and it has been used in neonates,[9] children,[10] and adults having both cardiac and noncardiac surgery.[11]

Nasopharyngeal probes typically are inserted through 1 nostril. But curiously, there is no consensus on how deeply to insert the probe.[9,10,12] Insertion depth is likely to influence the accuracy of nasopharyngeal temperature measurements because probes near the nares will be cooled by ambient air; similarly, deeply inserted probes may approach the airway and be cooled by ventilation gases. We thus determined the range of nasopharyngeal probe insertion depths that best approximate reference core temperature measured in the distal esophagus.

METHODS

The study was conducted with approval of Cleveland Clinic IRB (Cleveland, OH) and with written consent from participating patients. We considered adults <80 years old who were scheduled for elective noncardiac surgery at the Cleveland Clinic Main Campus. We included patients having supine surgery scheduled to last ≥90 minutes with general anesthesia and endotracheal intubation. Enrollment started January 2014 and finished December of the same year.

Exclusion criteria were as follows: (1) preexisting nasopharyngeal disease; (2) upper-airway abnormalities; (3) planned nasopharyngeal surgery; (4) recent substantive epistaxis; (5) history of serious coagulopathy; (6) presence of upper esophageal disease except gastroesophageal reflux; (7) therapeutic-dose anticoagulation; and (8) contraindications to esophageal temperature probe placement.

Patients were asked to breathe sequentially through 1 nostril and then the other, and the side with better air flow was selected for nasopharyngeal probe placement (details below). The right nostril was set as the default side if no difference was found. General anesthesia was managed at the discretion of the attending anesthesiologist. All patients were warmed with forced air. Patients' faces were not directly heated or covered. Operating room temperature was maintained at

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Accepted for publication January 6, 2016.

Funding: Internal.

The authors declare no conflicts of interest.

Reprints will not be available from the authors.

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DOI: 10.1213/ANE.0000000000001213

approximately 21°C. Nasogastric tubes were not used. A few patients had an orogastric tube inserted at ≥50 cm at the beginning of the case. The stomach was suctioned, and the tube then clamped throughout the measurement period.

Esophageal thermistor probes (General Purpose Probe; Truer Medical Inc., Orange, CA) were used in both the esophagus and nasopharynx of each patient. The probe designated for the nasopharynx was marked with indelible ink from 2 to 20 cm at 2-cm increments from its tip. The probe designated for the esophagus was permanently marked 40 cm from its tip. The probes were then connected to the preassigned esophageal and nasopharyngeal channels of the clinical monitor in the designated operating room.

Both probes were inserted 10 to 20 cm, with their tips in close proximity, into a vigorously shaken prewarmed sterile normal saline bath at approximately 37°C. After 5 minutes, we confirmed that the temperatures from each probe differed by no more than 0.1°C. New temperature probes would have been selected had the differences been larger, but replacement was never required.

The esophageal temperature probe was inserted and secured with the 40-cm mark at the central incisors. The nasopharyngeal probe was inserted 20 cm and secured at the nares; direct laryngoscopy was used to confirm that the tip was in the pharynx.

The initial set of nasopharyngeal and esophageal temperatures was recorded ≥30 minutes after induction of anesthesia. Thereafter, the nasopharyngeal probe was withdrawn 2 cm at a time, at 5-minute intervals, while the esophageal probe remained at 40 cm. After each 5-minute equilibration period, another set of nasopharyngeal and esophageal temperatures was recorded. Each patient thus had 10 sets of esophageal and nasopharyngeal temperatures corresponding to nasopharyngeal distances ranging from 20 to 2 cm past the nares.

Race, sex, age, height, and weight also were recorded. Both temperature probes were removed at the end of the surgery. The oral cavity and oropharynx were suctioned, and the nostrils examined for trauma or bleeding.

Statistical Methods

We estimated the accuracy of nasopharyngeal probes at each depth as the difference between nasopharyngeal and esophageal temperatures. We a priori defined clinically acceptable accuracy for the nasopharyngeal probe as a mean ± 1.96 SD difference in temperatures between −0.5°C and 0.5°C. We do not report confidence intervals for the mean differences (or mean bias) because we were interested in the distribution of differences for individual patients rather than the distribution of the mean.

Mean differences of ±1.96 SD equals the Bland-Altman limits of agreement and indicates where 95% of individual differences are expected to occur in similar populations. Thus, mean temperatures ±1.96 SDs were plotted at each probe depth. When the entire mean ± 1.96 SDs temperature range was between −0.5°C and 0.5°C, we considered nasopharyngeal temperature to be accurate at that particular probe depth. As an example, accuracy of nasopharyngeal temperature at 16 cm was assessed by plotting esophageal temperature against nasopharyngeal temperature and constructing a formal Bland-Altman plot.

Table 1. Baseline Characteristics of the Study Population

Factors	(n = 36)
Age (yr)	55 ± 6
Gender (female)	26 (77)
Race	
Caucasian	33 (92)
Other	3 (8)
Body mass index (kg/m^2)	27.5 ± 6.1

Summary statistics presented as mean ± SD or n (%), as appropriate.

Table 2. Mean ± SD of Nasopharyngeal Temperature, Esophageal Temperature, and Difference in Temperatures Across Nasopharyngeal Probe Depths

Probe depth, cm	n[a]	Nasopharyngeal temperature (°C)	Esophageal temperature (°C)	Difference (°C)[b]
2	33	34.3 ± 1.68	36.1 ± 0.59	−1.82 ± 1.54
4	34	35.7 ± 0.87	36.1 ± 0.58	−0.69 ± 0.58
6	34	35.8 ± 0.65	36.1 ± 0.59	−0.24 ± 0.24
8	34	35.9 ± 0.58	36.1 ± 0.60	−0.14 ± 0.21
10	35	36.0 ± 0.55	36.0 ± 0.59	−0.06 ± 0.15
12	35	35.9 ± 0.52	36.0 ± 0.57	−0.06 ± 0.15
14	35	35.9 ± 0.49	35.9 ± 0.50	−0.05 ± 0.12
16	35	35.8 ± 0.48	35.9 ± 0.51	−0.10 ± 0.12
18	36	35.7 ± 0.50	35.8 ± 0.50	−0.12 ± 0.16
20	36	35.7 ± 0.46	35.8 ± 0.48	−0.11 ± 0.13

[a]Number of observations per probe depth. Three patients finished the procedure early, resulting in fewer available measurements.

[b]Difference in temperature is defined as nasopharyngeal temperature minus esophageal temperature.

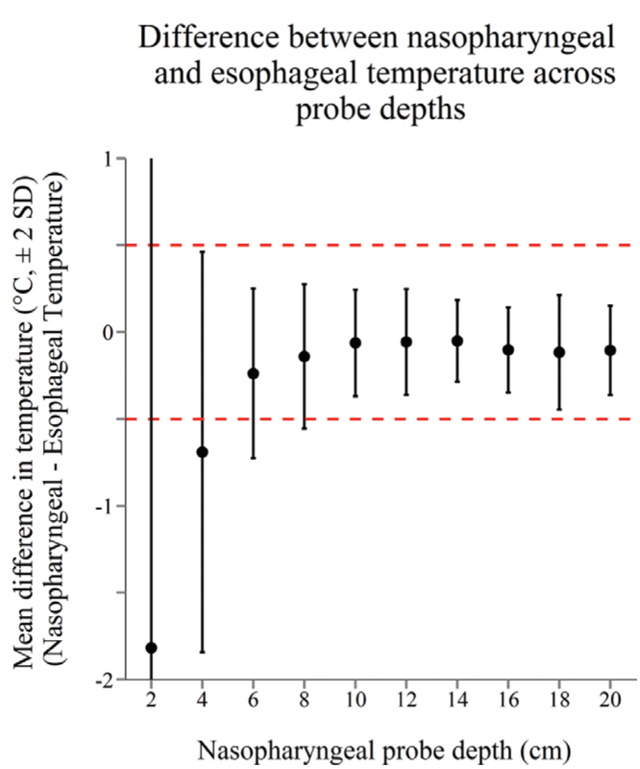

Figure 1. Mean difference between nasopharyngeal and esophageal temperatures ± 1.96 SD at decreasing probe depths. Nasopharyngeal probe depths where the mean ± 1.96 SD difference in temperature remains between 0.5°C and −0.5°C are defined as clinically acceptable. Among our patients, this includes depths between 10 and 20 cm.

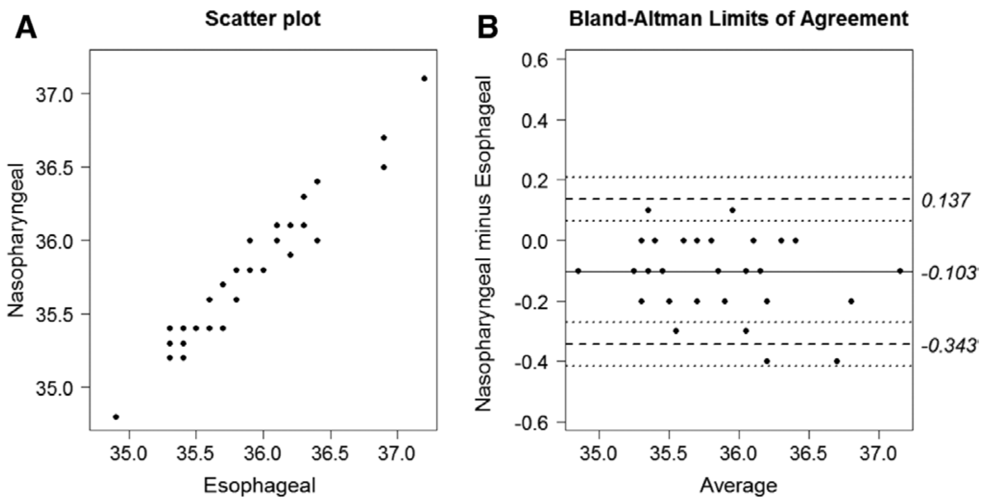

Figure 2. A, By using a nasopharyngeal probe depth of 16 cm as an example of accurate nasopharyngeal depth, we report a scatterplot of nasopharyngeal versus esophageal temperatures. B, Bland-Altman plot of nasopharyngeal versus esophageal temperatures at a 16-cm nasopharyngeal probe depth. Broad dashed lines are estimated Bland-Altman limits of agreement (mean difference ± 1.96 SD), indicating where 95% of observations are expected to fall. All points are within the clinically acceptable range (±0.5°C), and the distribution of differences does not appear to depend on the average of nasopharyngeal and esophageal temperatures. Narrower dashed lines give 95% confidence intervals for the limits of agreement, with 0.07–0.21 for the upper and −0.41 to −0.27 for the lower limit. These wider intervals also are within ±0.5°C.

The accuracy of nasopharyngeal temperature at varying probe depths also was assessed as a function of patient age, gender, and body mass index.

We designed the study to enroll 50 patients, which would have provided narrow 95% confidence intervals for the difference between methods at various insertion depths, assuming an SD of 0.5 for each method and correlation of 0.60 between methods. However, the principal investigator, a resident, was no longer able to enroll qualifying patients after December 2014. We thus conducted the analyses for this cohort study in the 36 patients then enrolled. There was stronger correlation between methods than we had expected originally. We consequently had excellent power for both specific aims, and enrollment was thus discontinued.

RESULTS

Among the 36 patients enrolled in the study, temperature measurements were missing at several probe depths in 3 patients because their procedure ended earlier than anticipated. Baseline characteristics of the study population are presented in Table 1. Table 2 presents the mean and SD of nasopharyngeal temperature, esophageal temperature, and the difference between temperatures at all probe depths considered in this study. Mean nasopharyngeal temperature was consistently lower than esophageal temperature, but mean differences (i.e., mean bias) were small (<0.15°C) for all depths >10 cm. In contrast, bias and variability were unacceptably large at shallow probe depths, especially at 2 and 4 cm past the nares.

At probe depths of 10 to 20 cm, the Bland-Altman limits of agreement, or mean difference ± 1.96 SD, were all between −0.5°C and 0.5°C (Fig. 1). Nasopharyngeal temperatures were thus accurate when the probe depth was between 10 and 20 cm, but variance from esophageal temperatures was excessive at shallower probe depths. As an example, at 16 cm, nasopharyngeal temperatures were quite close to esophageal temperatures (Fig. 2A), with a mean bias of 0.10°C and Bland-Altman limits of agreement (mean bias ± 1.96 SD) of −0.22°C to 0.02°C (Fig. 2B).

The accuracy of nasopharyngeal temperatures did not vary appreciably as a function of age, body mass index, or gender (Figs. 3–5).

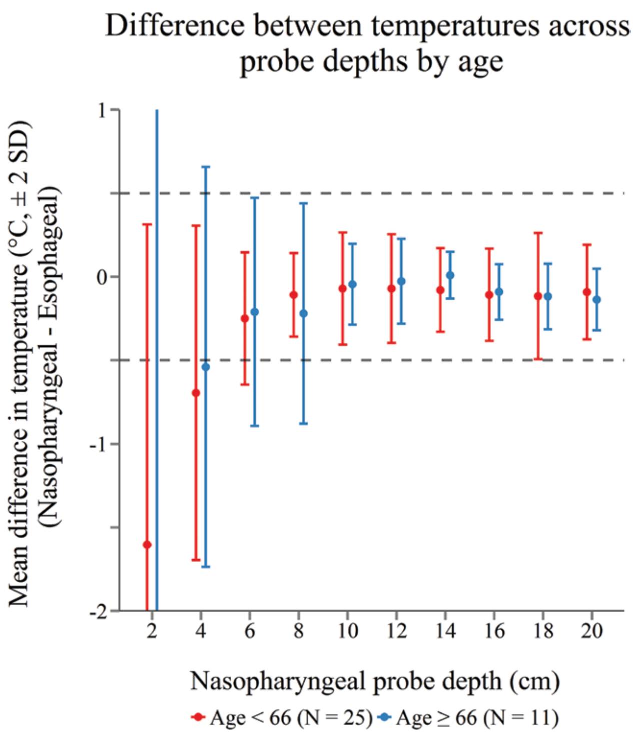

Figure 3. Mean difference ± 2 SD between nasopharyngeal and esophageal temperatures at decreasing probe depths, stratified by age. We defined nasopharyngeal probe depths as clinically acceptable where the mean ± 1.96 SD difference in temperature remains between 0.5°C and −0.5°C. Regardless of age, temperatures remained within the acceptable range when nasopharyngeal probe depth was between 10 and 20 cm.

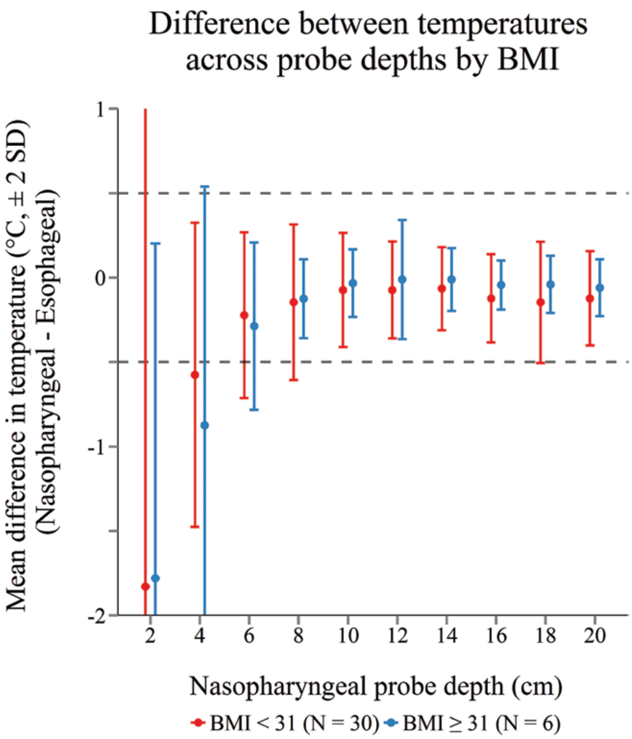

Figure 4. Mean difference between nasopharyngeal and esophageal temperatures ± 1.96 SD at decreasing probe depths, stratified by body mass index (BMI; kg/m^2). We defined nasopharyngeal probe depths as clinically acceptable where the mean ± 1.96 SD difference in temperature remains between 0.5°C and −0.5°C. Regardless of BMI, temperatures remained within the clinically acceptable range when nasopharyngeal probe depth was between 10 and 20 cm.

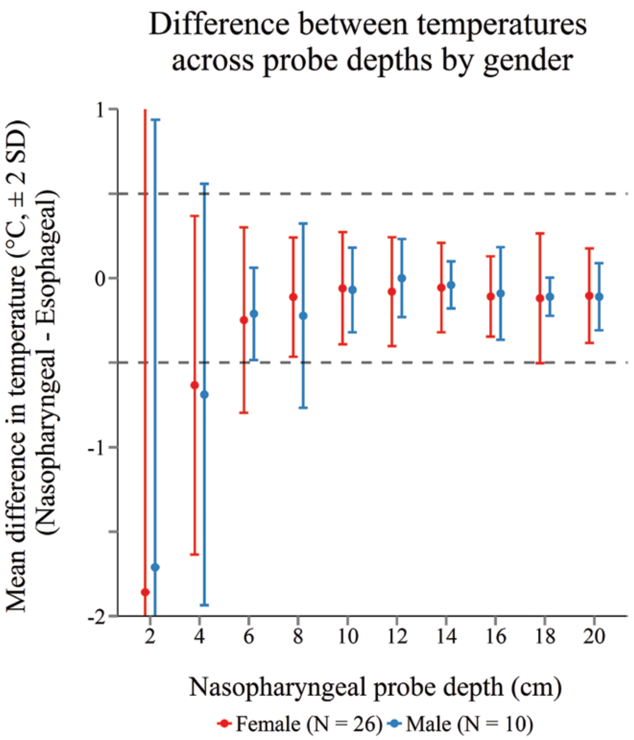

Figure 5. Mean difference between nasopharyngeal and esophageal temperatures ± 1.96 SD at decreasing probe depths, stratified by gender. We defined nasopharyngeal probe depths as clinically acceptable where the mean ± 1.96 SD difference in temperature remains between 0.5°C and −0.5°C. Regardless of gender, temperatures remained within the clinically acceptable range when nasopharyngeal probe depth was between 10 and 20 cm.

DISCUSSION

The nasopharynx has long been among the recommended and commonly used temperature monitoring sites[8] and is believed to accurately reflect core temperature because of its proximity to the brain.[6,7] Furthermore, the site is attractive because, unlike esophageal probes, nasopharyngeal probes can be inserted easily in patients with laryngeal mask airways. The nasopharynx also remains available for temperature monitoring in patients having esophageal manipulations such as during bariatric and other types of gastrointestinal surgery.

Within the range of 10- to 20-cm depth, mean nasopharyngeal temperatures were lower than esophageal temperatures, but only by approximately 0.1°C, which is a clinically meaningless amount. More importantly, the individual variability of the differences versus esophageal temperature was quite small within that depth range. Our results showed a mean difference ± 2 SD occurring well within −0.5°C and 0.5°C, implying that 95% of individual patient differences would be clinically unimportant.

Our primary result is thus that nasopharyngeal probe insertion depths between 10 and 20 cm provide temperatures that are consistently, across patients, nearly identical to reference distal esophageal temperatures during noncardiac surgery. Careful positioning of nasopharyngeal probes thus does not appear necessary. Any insertion distance between 10 and 20 cm can thus be substituted for esophageal temperatures for both clinical and research purposes.

Lee et al.[11] similarly reported that temperatures recorded from probes in the nasal cavity were cooler by approximately 0.2°C (95% confidence interval, 0.15°C –0.25°C) than those recorded from the distal nasopharynx. Our results extend this finding by showing that there is substantial bias and variability at probe insertion depths ≤6 cm. Consistent with this conclusion, Sato et al.[13] reported that nasopharyngeal temperatures at an insertion depth of 2 to 5 cm are unreliable in adults during cardiopulmonary bypass and that correlation with tympanic membrane temperature improved at deeper insertion depths. Others, however, reported that a 4-cm insertion depth was sufficient in noncardiac surgery,[14] although our results suggest that probes should be inserted considerably further. Ko et al.[9] found that nasopharyngeal temperature measured at the nose-ear distance reflects epidural temperature in piglets and human newborns if probes are positioned correctly. Available evidence thus suggests that adequate probe insertion is critical for accurate nasopharyngeal temperature measurements and that any distance between 10 and 20 cm is sufficient.

The accuracy of nasopharyngeal temperatures was independent of age (over the adult range), sex, and body mass index. Consistent with our conclusion, Lee et al.[11] reported little or no correlation between height and distance from the nares to the upper nasopharynx in either men or women. We were unable to assess race as a potential confounding factor because nearly all our enrolled patients were Caucasian;

however, it seems unlikely that the accuracy and precision of nasopharyngeal temperature monitoring will be substantively influenced by race.

Because the esophagus was our reference temperature monitoring site, we restricted enrollment to patients having endotracheal anesthesia; however, nasopharyngeal temperature monitoring may be most useful in patients with laryngeal mask airways and in those who require esophageal manipulation or hardware. There is no reason to expect that our results will not fully apply to such patients.

Our study was restricted to adults who were undergoing noncardiac surgery. Nasopharyngeal temperatures are considered core in infants and children, and in patients having cardiopulmonary bypass, but what range of insertion depths is suitable in such patients remains unknown. Sato et al.[13] studied nasopharyngeal temperatures in adults during cardiopulmonary bypass; however, their insertion depths were limited from 2 to 5 cm. Ko et al.[9] measured nasopharyngeal temperature in newborns, but they only used a depth equal to nose-ear distance. Therefore, proper nasopharyngeal probe positioning on these patients remains to be further clarified.

In summary, any nasopharyngeal probe insertion depth between 10 and 20 cm well represents core temperature in adults having noncardiac surgery.

DISCLOSURES

Name: Mi Wang, MD.
Contribution: This author helped design the study, conduct the study, analyze the data, and write the manuscript.
Attestation: Mi Wang has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.
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Contribution: This author helped conduct the study and analyze the data.
Attestation: Asha Singh has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
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Contribution: This author helped conduct the study.
Attestation: Hashim Qureshi has seen the original study data and approved the final manuscript.
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Attestation: Alexander Leone has seen the original study data and approved the final manuscript.
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Contribution: This author helped analyze the data.
Attestation: Edward J. Mascha has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
Name: Daniel I. Sessler, MD.
Contribution: This author helped design the study and write the manuscript.
Attestation: Daniel I. Sessler has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
This manuscript was handled by: Sorin J. Brull, MD.

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