NASOGASTRIC TUBE PLACEMENT

A Cross-Comparison of Verification Methods Used in Pennsylvania Hospitals and How They Align With Guidelines

By **Lea Anne Gardner**, PhD, RN[◆◇] & **Susan Wallace**, MPH[◇]

DOI: 10.33940/med/2021.9.4

Nasogastric tubes (NGTs) are used as an alternative approach to deliver nutrition and medications, or a method to remove stomach contents. Insertion of these tubes is considered a simple procedure; however, wrong placement or dislodged tubes can lead to patient harm and possibly death. The risk of harm and death increases when misplaced or dislodged tubes are not identified prior to using them. We queried the Pennsylvania Patient Safety Reporting System for events that occurred between January 1, 2017, and June 30, 2020. We analyzed those reports that provided supplemental information describing NGT placement verification methods to determine how these activities aligned with NGT guidelines. The use of X-rays and pH aspirate, guideline-approved verification methods, were identified in 90.8% (544 of 599) of the reports. In 9.2% (55 of 599) of the reports, the use of non-recommended verification methods (e.g., insertion of air bolus/auscultation, were identified). Reports indicated that patients aged less than one year old experienced a higher percentage of non-recommended verification methods being used when compared to all other patients. Interviews with staff at three healthcare facilities discussed their approach to verifying NGT placement. Risk reduction strategies comprise using the guideline recommendations to verify NGT placement and avoiding the use of non-recommended verification methods.

Keywords: *patient safety, nasogastric tubes, enteral feeding tubes, NG tube guidelines, NG tube verification*

◆Corresponding author
◇Patient Safety Authority
Disclosure: The authors declare that they have no relevant or material financial interests.

Nasogastric and orogastric tubes (hereafter collectively referred to as nasogastric tubes [NGTs]), offer an alternative approach to deliver nutrition and medication to patients or a method to remove stomach contents.[1] The size of the tube determines the function; small-bore tubes deliver enteral feedings, (i.e., nutrition),and large-bore tubes remove stomach contents.[2] NGT insertions are usually performed without the benefit of a visual aid, which can lead to tube misplacement in an unintended location, such as a lung. NGT misplacements are a known complication that can lead to iatrogenic injuries, such as a pneumothorax or perforations of the lung, esophagus, stomach, or other organs.[3,4]

Misplacements are not the only patient safety concern related to NGTs. The tube can also become dislodged or prematurely removed after verifying the proper location. This can happen when patients move, cough, vomit, or scratch their nose. Confused patients may accidentally pull the tube out partially or completely, or the tube can migrate out of place if the means of securing it fails.

Verification of an NGT location is essential after insertion and prior to using it for both newly inserted and preexisting NGTs to prevent patient harm. There are different evidence-based methods of verifying the NGT has been placed in the correct location. These approaches are summarized into recommendations and presented in clinical guidelines, which are an invaluable way to share current best practices with healthcare clinicians. One caveat to using guidelines is clinicians need to evaluate and determine how the recommendations align with their organization's policies and the patient's circumstances.[5-8]

This article evaluates Pennsylvania Patient Safety Reporting System (PA-PSRS)[a] event reports (hereafter referred to as reports) that contained descriptions of methods used when verifying NGT placement. These descriptions provide additional information associated with NGT events, such as whether they involved dislodged or misplaced tubes. This analysis was performed to identify what types of verification methods are being used and how they align with NGT guideline verification methods. However, the information contained within an event report is not a patient safety event by itself. In many cases, verification methods in our reports are not a contributing factor in the precipitating events.

Methods

PA-PSRS was queried using a three-step iterative process to search for reports stating NGT verification methods that occurred between January 1, 2017, and June 30, 2020.

1. An initial core set of keywords was used from a prior analysis of NGT misplacement events.[3] A random sample of reports were reviewed, leading to refinement of keywords[b] and exclusion criteria[c] to pinpoint reports describing NGT verification methods.
2. A second targeted data query was performed using the refined keywords and exclusion criteria. Orogastric and nasoduodenal tubes were included in the final dataset and are referred to as NGTs.
3. Manual review of the second data query identified reports with descriptions of NGT verification methods. In many cases, the verification method was not related to the patient safety event that occurred but was contained in supplemental information provided by the reporter. We excluded reports that mentioned the presence of an NGT; that referenced NGTs inserted or replaced with no information about what verification method(s) was used; and that referenced children with a diagnosis of ataxia-telangiectasia, a condition that places children exposed to radiation at increased risk for cancer. We also excluded reports describing misread X-rays and communication issues because they were outside the scope of this study.

Reports meeting inclusion criteria were divided into two categories: recommended methods of NGT verification (hereafter referred to as best practices) and non-recommended NGT verification methods. Category assignment was determined by the descriptions of activities used when verifying or reverifying a tube's location. Many reports described multiple occurrences of NGT placement and verification strategies. Reports describing even one non-recommended method were assigned to the non-recommended verification method category because the use of even a single non-recommended verification method is a patient safety concern.

We supplemented this analysis with interviews with healthcare staff at three facilities. We identified facilities based on prior experience with NGT insertions and recommendations from NGT nurse experts.

> Patients less than 1 year old experienced a higher percentage of non-recommended events when compared to patients in all other age groups.

[a] PA-PSRS is a secure, web-based system through which Pennsylvania hospitals, ambulatory surgical facilities, abortion facilities, and birthing centers submit reports of patient safety–related incidents and serious events in accordance with mandatory reporting laws outlined in the Medical Care Availability and Reduction of Error (MCARE) Act (Act 13 of 2002).9 All reports submitted through PA-PSRS are confidential and no information about individual facilities or providers is made public.

[b] The core set of keywords was: Dobhoff, DHT, duotube, Covidien, Keofeed, Keofed, Corflo, Cortrak, corpak, Salem Sump, naso*, nasogastric tube, ng tube, NGT, ND tube, OG, gastric tube, enteral, small bore, feeding tube, orogastric tube. These words were linked with this secondary set of keywords: position, placement, pneumo, lung, esoph*, bronch* thorax, KUB (kidney, urinary, bladder x ray), AXR (abdominal x ray), chest x ray, CXR, malposition, migrated, misplaced, replace, pleural, perforation, perforated, air bolus, auscultation, air bubbles, air auscultation, pH, check placement, confirm, and confirmation. The asterisk after a word represents a wildcard: This syntax searches for words with these letters and any ending.

[c] Exclusion criteria encompassed the following PA-PSRS event types: skin integrity, falls, transfusion, adverse drug reaction, and patient self-harm.

Results

Demographic Analysis

An initial exploratory data query identified 2,216 reports using the initial keywords. The number of reports was reduced to 1,363 reports after rerunning the query with refined keywords and exclusion criteria. We performed a manual review of the 1,363 reports and identified 599 reports that met inclusion criteria; 595 involved nasally inserted tubes and 4 involved orally inserted tubes. See **Figure 1**.

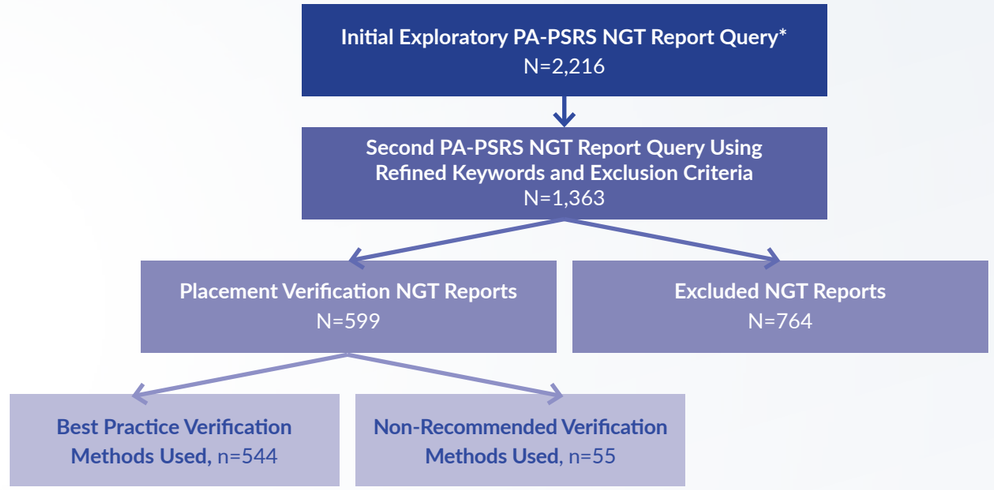
While non-recommended verification methods are the focus of this article, best practices were identified in 90.8% (544 of 599) of the reports. In 95.4% (519 of 544) of the reports reflecting best practice methods, X-rays alone were used; 2.2% (12 of 544) involved the use of X-rays and pH aspiration testing, and in 2.4% (13 of 544) pH aspiration testing alone was used. The remaining results describes information in the reports that included non-recommended verification methods.

Demographic data revealed male patients accounted for 56.4% (31 of 55) of reports and female patients accounted for 43.6% (24 of 55).

Given the number of reports that indicated non-recommended verification methods, the percentage of these practices were compared to the total number of reports by facility type. See **Table 1**.

A similar set of calculations was performed to determine the percentage of non-recommended verification method reports

Figure 1. PA-PSRS Nasogastric Tube Insertion and Placement Verification Report Identification, n=614



*An initial core set of keywords was used from a prior analysis of NGT misplacement events.[3]

Table 1. Percentage of Non-Recommended Methods in PA-PSRS Reports by Facility Type*

Hospital Facility Type	Best Practices	Non-Recommended Verification Methods	**Total Reports**	% of Non-Recommended Verification Methods
Acute Care	257	41	**298**	13.8%
Children's Acute Care	62	9	**71**	12.7%
Long-Term Acute Care	221	4	**225**	1.8%

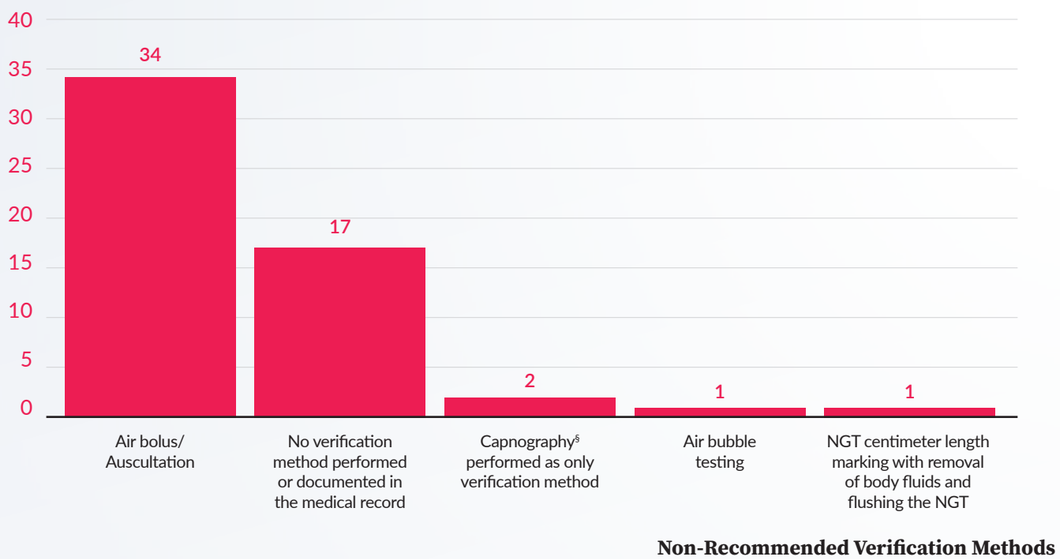
*Rehabilitation hospitals are not displayed in this table due to the small number of reports, n=5.
†One long-term acute care facility had 87 of the 255 reports submitted. Removing them from the calculation increased the percentage of non-recommended method reports from 1.8% to 2.9%.

Table 2. Percentage of Non-Recommended Verification Methods in PA-PSRS Reports by Patient Age

Patient Age Groups in Years	Best Practices	Non-Recommended Verification Methods	**Total Reports**	% of Non-Recommended Verification Methods
<1*	45	9	**54**	16.7%
1-19	38	5	**43**	11.6%
20-29	8	1	**9**	11.1%
30-39	14	2	**16**	12.5%
40-49	25	1	**26**	3.8%
50-59	67	7	**74**	9.5%
60-69	123	15	**138**	10.9%
70-79	138	9	**147**	6.1%
80-89	67	6	**73**	8.2%
90-101	19	0	**19**	0.0%

*Percentage for this age group is higher when compared to all other age groups combined, Z=1.997, p=0.046

Figure 2. Non-Recommended NGT Verification Methods in PA-PSRS Reports, n=55



§Capnography as an independent verification method is not recommended.[6,10-12] It can be used to detect pulmonary placement of an NGT,[6,8,10,11,13] but it cannot determine placement in the gastrointestinal tract, (i.e., esophagus, stomach, or small bowel placement).[8,10] Guidelines require a second form of best practice verification methods when using capnography to verify tube location.[6,10,11,14]

compared to the total number of reports by patient age groups. Patients under 1 year of age had the highest percentage of reports showing the use of non-recommended verification methods (16.7%; 9 of 54). The next age group, 30–39 years old, had the second highest percentage of non-recommended method reports (12.5%; 2 of 16). Patients less than 1 year old experienced a higher percentage of non-recommended events when compared to patients in all other age groups, z=1.997, p=0.046. See **Table 2**.

Qualitative Analysis

Non-Recommended NGT Verification Methods

The non-recommended verification methods were assigned to five categories: air bolus/auscultation, no verification method performed or documented in the medical record, capnography used as the only verification method, air bubble testing, and using the NGT centimeter marking with fluid removal and flushing. Air bolus/auscultation accounted for 61.8% (34 of 55) of the reports; no verification method performed or documented in the medical record accounted for 30.9% (17 of 55) of the reports; and capnography, air bubble testing, and using the NGT centimeter marking with fluid removal and flushing accounted for the remaining reports, 7.3% (4 of 55). See **Figure 2**.

Additional noteworthy information was contained in 10 of these reports. Two of the air bolus/auscultation reports identified the use of a normal saline solution flush during the verification process. Of the 17 reports with no verification method performed or documented in the medical record, 4 identified that NGTs were used. We also found 4 reports describing patients with NGTs in their lung who did not show respiratory symptoms immediately or who started showing symptoms only after a feeding or medication had been administered.

The following are descriptions[d] from some of the PA-PSRS reports reflecting non-recommended verification methods:

- *RN noticed tube was secured at 22 cm not 38 cm. X-ray confirmation of tube placement was done yesterday. This morning, the patient's oxygen was increased due to a respiratory episode overnight. The tube was removed, and another tube was inserted. MD was asked if a chest x-ray should be ordered. The physician said no since the patient was comfortable on oxygen. The nurse will continue to monitor patient.*
- *RN attempted Dobhoff tube placement. Placement checked by air injection into the tube. Air sounds heard over mid epigastric area. Chest x-ray demonstrated the tube was likely in the right main stem bronchus. Patient had a moderate pneumothorax.*
- *Patient's family told RN they were concerned that the NGT was not in the right place. RN explained that the NGT placement is determined by checking stomach pH. Family told the nurse that the nurse who placed the tube checked by 'using air and listening.' An x-ray was ordered. NGT was found in the patient's esophagus.*
- *NGT placed at bedside. No x-ray was done to confirm placement. The next day, the patient went to fluoroscopy and the NGT was discovered to be in the left mainstem bronchus. The NGT was not used to administer any feedings or fluids.*
- *NGT was attempted twice with capnography to verify placement. The patient began coughing. Oxygen was increased and physician was notified. A chest x-ray was performed and showed a new pneumothorax.*

Discussion

NGT guidelines identify best practices for verifying tube placement.[2,6,7,12,14-21] In 90.8% of the PA-PSRS reports, best practices were used when verifying NGT placement. The preferred choice of verification methods based on recommended guidelines differs geographically. The United Kingdom prefers pH aspirate testing as an indicator of proper placement,[16,22,23] whereas the United States prefers radiography as the gold standard.[2,6] There are also differences in preferred methods identified in adult and pediatric guidelines.[12,13] For this analysis, adult and pediatric reports are combined since most reports identified adult-preferred verification methods (i.e., X-rays); only a small number of reports identified pediatric-preferred verification methods (i.e., pH aspiration testing).

Insertion of an NGT starts with determining the length of tube needed to reach the stomach.[12,13] We acknowledge that for some patients tubes are ordered to be placed into the small intestine; however, this discussion focuses on NGTs with an intended location in the stomach, as these are the most common. The Nose→Earlobe→Xiphoid process→Midline of the Umbilicus (NEMU) method is recommended for determining the NGT insertion length.[10,12,13,24] It is recommended after confirmation of the tube location to place a visible centimeter (cm) mark on the tube where it exits the nose or lips.[10] This mark should be documented in the chart and can be used as a reference point to detect any movement of the tube.[10] While tube markings are important, they are not a verification method.

Two frequently used best practices for verifying NGT placement are radiography and pH aspirate testing.[2,6,8,10-12,24,25] Each method has specific requirements to use successfully. Radiography is the gold standard in the United States; however, there are concerns about radiation exposure and interpretation. In the pediatric population, concerns about using X-rays arises from uncertainty regarding cumulative radiation exposure[26] and the accurate and consistent interpretation of X-rays.[12] For example, people diagnosed with ataxia-telangiectasia, a rare genetic disorder, are predisposed to developing cancer.[27] Children, often before age 5, may show signs and symptoms of this condition.[27,28] Individuals with this disorder have increased sensitivity to X-rays,[27] which can be cytotoxic[29] and should be avoided or used only after careful consideration.[28]

The second best practice, pH aspirate testing, is a practical and feasible bedside method to confirm tube placement.[8] The pH cutoff value varies with guidelines. One guideline[8] identifies a pH ≤5 as the cutoff, four guidelines[7,10,12,15] identify a pH ≤5.5 as a cutoff, and one guideline[10] indicates that if pH test strips only provide round numbers, the cutoff value is a pH of ≤5. When pH readings are ≥5.5, radiography is recommended.[10,12,15] Using pH aspirate approved testing strips are essential when evaluating pH aspirate.[7,10,15,18,30,31] Litmus paper is an unreliable method of

[d]The details of the PA-PSRS event narratives in this article have been modified to preserve confidentiality.

> Our analysis showed air bolus/auscultation and air bubble testing were used to confirm location of an NGT. These verification methods are no longer recommended due to low reliability.

evaluating pH aspirate and has led to administering feedings, medications, or fluid in the lung due to incorrect results.[30]

Capnography is another method that can identify whether the NGT is in the lung or bronchi, but does not verify its location in the esophagus or stomach.[8,10,11,13,17] Some guidelines indicate the use of capnography requires a second form of verification.[2,11,14,25] Capnography is identified for use in adults;[2] however, the use in children is inconclusive.[32]

Another option to verifying placement is electromagnetic placement devices (EMPD). These devices use electromagnetic guidance to visualize the tip of the NGT by projecting the image on an external monitor. In 2018, the Food and Drug Administration (FDA) issued an alert about adverse events, (i.e., increased numbers of pneumothoraces), associated with the Cortrak device.[21] The FDA recommended prerequisite training and credentialing.[21] Research indicates that healthcare clinicians trained to use the Cortrak, identified as "super users," have shown reductions in adverse events and improvements in NGT insertions.[33]

When it comes to non-recommended verification methods, our analysis showed air bolus/auscultation and air bubble testing were used to confirm location of an NGT. These verification methods are no longer recommended due to low reliability.[2,5,6,8,10-12,15,16,25,34-36] Air bolus/auscultation, also known as the "whoosh test,"[8] is a method of injecting air into the NGT and listening with a stethoscope for a sound of air over the epigastric area.[2,5,6,8,10,15] Our findings revealed over half of the non-recommended verification methods were due to using the whoosh test. A recent national survey of critical care nurses identified 76% of respondents performed air auscultation to verify NGT placement and 88% of respondents observed colleagues performing air auscultation as a verification method.[35] The air bubble test is performed by placing the external end of the NGT in a cup of water to see if air bubbles appear, thereby indicating the tube is in the lung.[10,15] Another method of verification not supported in guidelines is observing the appearance of feeding tube aspirate, including the color and consistency of gastric aspirate.[11,12,14-16]

The presence of respiratory symptoms is another unreliable verification method.[6,8,10,11,16,25] A recent study of misplaced NGTs revealed 21.4% of adverse event reports identified patients experiencing respiratory and/or cardiac symptoms when diagnosed with a pneumothorax resulting from a misplaced NGT.[37] In this analysis, we identified patients with NGTs in their lung who did not show respiratory symptoms immediately or who started showing symptoms only after a feeding or medication had been administered.

Our analysis revealed a significantly higher percentage of non-recommended reports for patients in the less than 1 year age group than for all other age groups combined. Patients in this age group are vulnerable given their size and inability to verbalize discomfort with a misplaced tube. Using best practices can improve the chance of correctly identifying an NGT's location.

NGT Verification Field Experience

We interviewed representatives from three different healthcare facilities to discuss their approaches[e] and methods to verify NGT placement. Two of the facilities addressed methods used for adult patients and the third facility addressed methods for children.

Trained staff at one healthcare system in Pennsylvania uses a two-step method to verify the location of the NGT. Staff measures and inserts the tube to 30 cm followed by a chest X-ray. If the X-ray confirms the tube is still in the esophagus and has not entered the bronchi or lung, the tube is inserted to the final measured length. A second X-ray of the abdomen is taken to confirm that the NGT has entered the stomach. Staff decided to use this two-step method in 2013 after the facility experienced misplacements after switching to a different manufacturer's enteral feeding delivery system.

Thomas Jefferson University Hospital staff has a clinical practice guideline for insertion of small-bore feeding tubes in vulnerable populations which outlines criteria for use of Cortrak and the two-step X-ray method in vulnerable populations. The two-step X-ray method is an alternative method to confirm NGT placement when a Cortrak super user is not available, according to Heather Etzl, MSN, RN, and Jacqueline Crawford, MS, RN, nutritional support clinical nurse specialists, and Shawn Mangan, MSN, RNFA, Thomas Jefferson University Hospital. NGT insertions for high-risk patients are performed by super users who are specifically trained in the use of the Cortrak EMPD. This EMPD is an electromagnetic sensor-guided device in which an electromagnetic stylet provides real-time location information on the tube tip placement within a patient's anatomy. All patients having an NGT inserted require an abdominal X-ray to confirm gastric placement.[38]

Children's Hospital of Philadelphia (CHOP) staff uses the NEMU method when placing an NGT, according to Sharon Irving, PhD, CRNP, who has authored papers on NGT location verification methods for children.[12] Irving said this insertion-length method is followed by the measurement of the acidity or pH of the gastric aspirate. If the aspirate pH is greater than 5.5 or if there is any concern regarding tube location, an X-ray is taken using radiation as low as reasonably achievable to determine tube and tube tip location. An X-ray is also obtained for any patient in which there is clinical status concern for correct NGT placement.[39]

To provide the safest care for patients, staff must be aware of and know how to implement the best practices for NGT placement and verification.

[e] This information is being shared because it may help to advance patient safety; however, it does not constitute an endorsement or formal recommendation by the authors or the Patient Safety Authority.

Best Practice NGT Placement Method

1. Use the NEMU method to measure an NGT's insertion length. This activity determines the length necessary to guide how far the tube should be inserted; however, inserting the tube to the measured length is not a guarantee that the NGT has reached its intended location.[12,34,36]
2. Place a marking on the NGT where it exits the nose or lips as a reference point to see if it has moved. Document this information in the chart.[10]

Best Practice NGT Verification Methods

1. Utilize guideline-recommended verification methods to confirm the tube's location with every newly inserted NGT, prior to using a preexisting tube, or if tubes are not at the reference centimeter mark.[10]
2. Recheck the tube's location every four hours after feedings have begun,[6,10,25] before administering each feeding, when feedings are interrupted,[6,10] giving medications,[16] or when the centimeter mark on the tube has moved.[6,10]
3. Use approved pH testing strips.[7,15,18] Do not use litmus paper,[36] as it does not provide accurate results.[7,10,16,23]
4. Work with clinicians to set up a process for pH aspiration testing so this method of verification is easy to initiate and document.
5. Consider radiography even if a pH is in the required range when the patient[10]
    a. Is severely obtunded (has an altered level of consciousness).
    b. Has an endotracheal tube.
    c. Is clinically unstable after NGT reinsertion post resuscitation.
    d. Has clinical deterioration soon after NGT placement.
6. Include another best practice to accompany capnography.[6,14,15]

Non-Recommended NGT Verification Methods (Not Approved for Use)

1. Air auscultation[2,5-8,10-13,15,16,23,24,34,36] and checking for air bubbles,[6,16,36] (i.e., placing the NGT in a glass of water).
2. The lack of respiratory symptoms is not an indication that the NGT is not in the lung.[6,15,16]
3. Interpretation of the appearance of aspirate is not reliable to determine NGT placement.[12,15,16,23]
4. Fluids of any kind (e.g., enteral feeds, normal saline solution, water, are not to be injected into the NGT for any reason prior to confirming the location of the tube).
5. Capnography as an isolated verification method is not approved as an evidence-based method.[6,11,12,14]

Limitations

PA-PSRS reports provide a wealth of information about the type of verification methods facilities use to determine NGT placement. The reports used in this analysis were identified searching keywords related to NGTs because there are no structured data fields specific to NGT-related reports. Calculating overall rates of best practices and non-recommended verification methods is not feasible because data on the number of NGT insertions is unknown and events containing this type of information may be underreported.

Conclusion

NGT insertion may appear to be a simple procedure; however, misplacement of the tube can lead to life-threatening emergencies or death. NGT verification after insertion or reverifying placement of existing tubes is an essential step to confirm proper location of the tube prior to use. Our analysis has shown that best practice verification methods are overwhelmingly being implemented in Pennsylvania facilities. Staff at three different organizations shared their expertise about insertion techniques and implementation of NGT best practices. Even though best practices are being used, we found instances of staff using non-recommended verification methods to confirm location of the tube tip. Staff may be unaware of changes in guidelines reflecting best practices. Evaluating organizational policies and procedures coupled with training can identify opportunities to ensure staff know and implement best practices when verifying NGT placement. Ending the use of non-recommended NGT tube placement verification methods is necessary to reduce the risk of patient injuries associated with NGTs.

Note

This analysis was exempted from review by the Advarra Institutional Review Board.

References

1. Price G, Shuss S. The Ins and Outs of NG Tubes. *Nursing Made Incredibly Easy*. 2016;14(5):52-4.

2. ENA Clinical Practice Guideline Committee et al. Clinical Practice Guideline: Gastric Tube Placement Verification. J Emerg Nurs. 2019 May;45(3):306.e1-306.e19. doi: 10.1016/j.jen.2019.03.011.

3. Wallace S. Data Snapshot: Complications Linked to Iatrogenic Enteral Feeding Tube Misplacements. *Pa Patient Saf Advis*. 2017;14(4):1-5.

4. Wallace S. Training Suggested When Changing Brands of Enteral Feeding Tubes. *Pa Patient Saf Advis*. 2014;11(2):78-81.

5. Simons SR, Abdallah LM. Bedside Assessment of Enteral Tube Placement: Aligning Practice with Evidence. *AJN*. 2012;112(2):40-6.

6. AACN Clinical Resources Task Force. AACN Practice Alert: Initial and Ongoing Verification of Feeding Tube Placement in Adults. American Association of Critical-Care Nurses; 2015. p. e8-e13.

7. Guidelines and Audit Implementation Network (GAIN). *Guidelines for Caring for an Infant, Child, or Young Person Who Requires Enteral Feeding*. 2015 1-44.

8. Boeykens K. Verification of Blindly Inserted Nasogastric Feeding Tubes: A Review of Different Test Methods. *J Perioper Crit Intensive Care Nurs*. 2018;4(3). doi: 10.4172/2471-9870.10000145.

9. Pennsylvania General Assembly. Medical Care Availability and Reduction of Error (MCARE) Act, Pub. L. No. 154 Stat. 13. 2002. https://www.health.pa.gov/topics/Documents/Laws%20and%20Regulations/Act%2013%20of%202002.pdf. Accessed August 19, 2021.

10. Lyman B, Visscher D, Barker SJ, Bennett M, Betts R, Coffey H, Goldstein M, Gorsuch K, Healey F, Naves LK, Longley A, Lopez J, Lounsbury O, McGinnis C, Moomjian R, Nadeau B, Peruzzi W, Peyton C, Prosser D, Sankaran S, Stade, C, Tatro J, Thorpe S, Wacker J. Actionable Patient Safety Solutions (APSS) #15: Nasogastric Tube (NGT) Placement and Verification. Patient Safety Movement Foundation; 2020. p. 1-16. https://patientsafetymovement.org/wp-content/uploads/2017/10/APSS-15-4.pdf. Accessed August 19, 2021.

11. Metheny NA, Krieger M, Healey F, Meert KL. A Review of Guidelines to Distinguish Between Gastric and Pulmonary Placement of Nasogastric Tubes. *Heart Lung*. 2019;48(3):226-35. doi: 10.1016/j.hrtlng.2019.01.003.

12. Irving SY, Rempel G, Lyman B, Sevilla WMA, Northington L, Guenter P, The American Society for Parental and Enteral Nutrition. Pediatric Nasogastric Tube Placement and Verification: Best Practice Recommendations From the NOVEL Project. *Nutr Clin Pract.* 2018;33(6):921-7. doi: 10.1002/ncp.10189.

13. Lyman B, Yaworski J, Duesing L, Moore C. Verifying NG Feeding Tube Placement in Pediatric Patients. *Am Nurse Today*. 2016;11(1):1-3.

14. Boullata JI, Carrera AL, Harvey L, Hudson L, McGinnis C, Wessel JJ, Bajpai S, Kin TJ, Klang MG, Martin K, Pompeii-Wolfe C, Wood A, Guenter P, Therapy Task Force. ASPEN Safe Practices for Enteral Nutrition Therapy. *JPEN J Parenter Enteral Nutr.* 2017;41(1):15-103. doi: 10.1177/0148607116673053.

15. National Health Service (NHS). Resource Set: Initial Placement Checks for Nasogastric and Orogastric Tubes. 2016. https://web.archive.org/web/20201209123051/https://improvement.nhs.uk/documents/193/Resource_set_-_Initial_placement_checks_for_NG_tubes_1.pdf. Accessed August 19, 2021.

16. New South Wales (NSW) Government Health. Infants and Children Insertion and Confirmation of Placement of Nasogastric and Orogastric Tubes [GL2016_006}. 2018. http://cedd.org.au/wordpress/wp-content/uploads/2015/04/Infants-and-Children-Insertion-and-Confirmation-of-Placement-of-Nasogastric-and-Orogastric-Tubes.pdf. Accessed August 19, 2021.

17. The Intensive Care Society. *Standards for Capnography in Critical Care.* 2018. https://www.medacx.co.uk/sites/default/files/product-pdfs/capnography_standards_for_critical_care_1.pdf. Accessed August 19, 2021.

18. National Nurses Nutrition Group (NNNG). *Good Practice Guideline: Safe Insertion and Ongoing Care of Nasogastric (NG) Feeding Tubes in Adults*. 2016. https://web.archive.org/web/20191101064517/http://www.nnng.org.uk/wp-content/uploads/2016/06/NNNG-Nasogastric-tube-Insertion-and-Ongoing-Care-Practice-Final-Aprill-2016.pdf. Accessed August 19, 2021.

19. McClave SA, DiBaise JK, Mullin GE, Martindale RG. ACG Clinical Guidelines: Nutrition Therapy in the Adult Hospitalized Patient. *Am J Gastroenterol*. 2016;111(3):315-34. doi: 10.1038/ajg.2016.28.

20. Burgos R, Bretón I, Cereda E, Desport JC, Dziewas R, Genton L, Gomes F, Jesus P, Leischker A, Muscaritoli M, Poulia KA, Preiser JC, Van der Marck M, Wirth R, Singer P, Bischoff SC. ESPEN Guideline Clinical Nutrition in Neurology. *Clin Nutr.* 2017;37:354-96.

21. U.S. Food and Drug Administration. Feeding Tube Placement Systems - Letter to Health Care Providers. 2018. https://www.fda.gov/medical-devices/letters-health-care-providers/feeding-tube-placement-systems-letter-health-care-providers#:~:text=For%20Enteral%20Access%20Systems%2C%20the,place%20an%20enteral%20feeding%20tube. Accessed August 19, 2021.

22. National Health Service (NHS). Patient Safety Alert: Nasogastric Tube Misplacement: Continuing Risk of Death and Severe Harm. 2016. https://www.england.nhs.uk/wp-content/uploads/2019/12/Patient_Safety_Alert_Stage_2_-_NG_tube_resource_set.pdf. Accessed August 19, 2021.

23. National Health Services (NHS). Patient Safety Alert NPSA/2011/PSA002: Reducing the Harm Caused by Misplaced Nasogastric Feeding Tubes in Adults, Children, and Infants. 2011. http://www.gbukenteral.com/pdf/NPSA-Alert-2011.pdf. Accessed August 19, 2021.

24. Lyman B, Peyton C, Healey F. Reducing Nasogastric Tube Misplacement Through Evidence-Based Practice. *Am Nurse Today*. 2018;13(11):6-11.

25. Bourgault AM, Heath J, Hooper V, Sole ML, NeSmith EG. Methods Used by Critical Care Nurses to Verify Feeding Tube Placement in Clinical Practice. *Crit Care Nurse*. 2015;35(1):e1-e7. doi: 10.4037/ccn2015984.

26. Kleinerman RA. Cancer Risks Following Diagnostic and Therapeutic Radiation Exposure in Children. *Pediatr Radiol*. 2006;36:121-5. doi: 10.1007/s00247-006-0191-5.

27. National Institutes of Health Genetic and Rare Diseases Information Center. Ataxia Telangiectasia 2021. https://rarediseases.info.nih.gov/diseases/5862/ataxia-telangiectasia. Updated January 28, 2021. Accessed July 15, 2021.

28. Children's Hospital of Philadelphia. Ataxia-Telangiectasia 2021. https://www.chop.edu/conditions-diseases/ataxia-telangiectasia. Updated January 28, 2021. Accessed July 15, 2021.

29. Rothblum-Oviatt C, Wright J, Lefton-Greif MA, McGrath-Morrow SA, Crawford TO, Lederman HM. Ataxia Telangiectasia: A Review. *Orphanet J Rare Dis.* 2016;11(159):1-21. doi: 10.1186/s13023-016-0543-7.

30. Jones BJM, Relph W, Small M, Colby J, Taylor S, Cartwright A, Anderson L, Mensforth A, Edwards P, Murray-Ashby G. A Position Paper on Nasogastric Tube Safety: Time to Put Patient Safety First. United Kingdom: BAPEN; 2020.

31. Healthcare Safety Investigation Branch. Interim Bulletin: Placement of Nasogastric Tubes. 2020. https://www.hsib.org.uk/investigations-and-reports/placement-of-nasogastric-tubes/. Accessed August 19, 2021.

32. Wathen B, Peyton C. Pediatric Nasogastric Tube Placement: Nutrition and Medication Without Complications. *Nurs Crit Care*. 2014;9(3):15-8. doi: 10.1097/01.CCN.0000446246.61200.91.

33. Bourgault AM, Gonzalez L, Aguirre L, Ibrahim JA. Cortrak Superuser Competency Assessment and Training Recommendations. *AJCC*. 2019;28(1):30-40. doi: 10.4037/ajcc2019170.

34. Irving SY, Lyman B, Northington L, Bartlett JA, Kemper C, NOVEL Work Group. Nasogastric Tube Placement and Verification in Children: Review of the the Current Literature. *Nutr Clin Pract.* 2014;29(3):267-76. doi: 10.1177/0884533614531456.

35. Bourgault AM, Powers J, Aguirre L, Sebastian AT. National Survey of Feeding Tube Verification Practices. *Dimens Crit Care Nurs.* 2020;39(6):329-38. doi: 10.1097/DCC.0000000000000440.

36. Lounsbury O, Tatro J, Lyman B, Prosser DM, Coffey H. Clinical and Nonclinical Implications of Misplaced Nasogastric Tubes: Tools for Implementation of Standardized Best Practices. *Patient Saf*. 2020:64-7. doi: 10.33940/med/2020.9.6.

37. Gardner L, Wallace S. Data Snapshot: Nasogastric Tube Misplacements. *Patient Saf* 2021;3(1):79-83. doi: 10.33940/data/2021.3.8.

38. Etzl H, Crawford J, and Mangan S. Nutritional Support CNSs and CRNP, respectively, at Thomas Jefferson University Hospital. Conversation with authors. December 8, 2020.

39. Irving S. PhD, MSN, CRNP; Associate Professor of Pediatric Nursing and Vice-Chair, Department of Family and Community Health at Children's Hospital of Philadelphia. Conversation with authors. December 4, 2020.

About the Authors

Lea Anne Gardner (leagardner@pa.gov) is a patient safety analyst with the Patient Safety Authority. She has more than 30 years of research experience in patient safety, performance improvement, cardiology, and behavioral health, and a diversified work experience, including roles as a national director of quality improvement, nursing, and population health; an institutional review board administrative director; a coronary intensive care nurse; a clinical research nurse; and a nurse research/leadership preceptor.

Susan Wallace is a senior patient safety liaison with the Patient Safety Authority (PSA) and a core team lead for the PSA's Center of Excellence for Improving Diagnosis. She is a Certified Professional in Healthcare Risk Management (CPHRM) and a Certified Professional in Patient Safety (CPPS).