# RELIABILITY OF PH MEASUREMENT AND THE AUSCULTATORY METHOD TO CONFIRM THE POSITION OF A NASOGASTRIC TUBE

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**Keywords:** nasogastric tube, pH measurement, auscultatory method

## Abstract:

**Background:** Blind placement of a nasogastric feeding tube is a common nursing procedure. Confirmation of the correct position in the stomach is warranted to avoid serious complications such as misplacement in the lung. Bedside pH measurement of aspirate is one of the techniques to confirm the tip position. The purpose of this study was to evaluate the auscultatory method and pH measurement with a pH cutoff point of 5.5 after tube insertion and to compare this with the 'gold standard': an abdominal x-ray. Also the feasibility of the pH method was evaluated.

**Materials and Methods:** Large prospective observational study in a general hospital. The positioning of 331 feeding tubes was tested using two different methods to predict tube position in the stomach.

**Results:** In 98.9% of aspirate samples with a pH ≤ 5.5 the tube was located in the stomach. The results of all pH measurements showed a sensitivity of 78.4% with a specificity of 85.7%. Obtaining aspirate initially after placement was possible in approximately half of cases but after taking additional measures (including administration of air into the tube, side-positioning of the patient and re-aspiration after one hour) this increased to 82.2%. The specificity of the auscultatory method for misplacement was only 46.2%.

**Conclusions:** A pH of ≤ 5.5 from tube aspirate is adequate to check the position of the tube in the stomach. Additional measures improve the success to obtain an aspirate from the tube.
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Non-standard abbreviations:

NG: Nasogastric

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Keywords: nasogastric tube, pH measurement, auscultatory method
**Clinical Relevancy Statement**

This study strongly supports the use of pH-measurement to reduce the harm caused by misplaced nasogastric feeding tubes.

**1. Introduction**

Nasogastric (NG) intubation is a common procedure in those patients who are not or not sufficiently able to swallow. The NG tube is used for the administration of tube feeding, fluids and medications. Even though blind intubation is considered relatively harmless and safe, incorrect positioning can have serious or even lethal consequences. The auscultation method is often used to determine correct positioning of the nasogastric tube. Numerous studies indicate however that this method may lead to false interpretations. An abdominal x-ray is often considered to be the ‘gold standard’, but radiation exposure, higher costs, misinterpretation and possible discomfort in vulnerable patients, are important disadvantages. Determining the pH from a gastric aspirate is a suitable alternative to determine correct positioning and is advocated as a first line test. Some guidelines or alerts, based on expert opinion or consensus, suggest a pH of 5.5 or less to confirm the correct gastric positioning of the tip of the tube. However, large studies investigating reliability and feasibility of pH measurement with this cut-off point to determine if the tube is located in or outside the stomach are lacking. The main aim of this study was to evaluate the reliability of pH measurement after nasogastric tube insertion with a pH 5.5 as cut-off point. The results were compared with those of the auscultation method and radiologic verification. A secondary aim was to test the feasibility of the bedside pH-measurement method.
2. Materials and methods

2.1 Patients

This prospective observational study was conducted from September 2009 until the end of December 2012 at the AZ Nikolaas Hospital in Sint-Niklaas (Belgium). Preliminary findings from this study were earlier published in a scientific nursing journal in December 2012.15.

A total of 331 nasogastric tubes were placed in patients (≥18 years) who had been admitted to hospital. All nasogastric tubes were ordered by the attending physician (for tube feeding, water and/or medications) and placed and controlled for positioning by, or placed and controlled under supervision of the same advanced practice nurse. All participants had been prescribed a nasogastric tube by their attending physician for tube feeding, water and/or medications. The study was approved by the Ethical Committee of the AZ Nikolaas Hospital in Sint Niklaas and all patients or their legal representatives signed an informed consent.

2.2 Materials and protocol

All placed nasogastric tubes were made from radio-opaque polyurethane (PUR) 10 or 14 Charrière (CH) with a guide wire (Flocare, Nutricia®). The tubes were placed in conscious, somnolent or comatose patients. Only those conscious patients who exhibited no swallowing problems were asked to drink a sip of water through a straw during placement of the tube to promote the passing of the tube from the throat into the esophagus. The length of tube to be passed was initially estimated using the NEX-method (nose-earlobe-xiphoid). In this method the distance between the nose and the earlobe and the earlobe to the bottom of the xiphisternum is measured. This insertion-length predictor remains the most commonly used method in clinical practise.16,17 After placement of the nasogastric tube the guide wire was removed to facilitate aspiration. The nasogastric tube was then fixed to the nose. For aspiration a large syringe (60 ml) with a conical end was used. Slow aspiration using a large
syringe, as opposed to a smaller syringe, usually prevents the adhesion of the gastric mucosa
to the tip of the nasogastric tube. In those cases where no aspirate could initially be
obtained, the procedure was repeated several times. If aspiration was successful, a few drops
of the aspirate were placed on a pH testing strip (Merck® pH indicator strip/pH 2.0-9.0) with
a colour 0.5 pH units scale. When the pH was found to be ≤ 5.5, it was assumed that the end
of the nasogastric tube was correctly situated in the stomach. When the results showed a pH ≥ 6.0, the aspirate was observed more closely. When the results showed a pH of ≥ 6, the
aspirate was observed and the colour and consistency were recorded. Subsequently, 20-30 ml
of air was administered through the tube and a stethoscope was used to listen for a bubbling
noise in the epigastrium. If a bubbling noise could be heard, a subjective distinction was
made between clear bubbling and inconclusive bubbling. In those cases where no aspirate
could be obtained after the auscultation, air was administered again (30 ml, maximum of 5
repetitions) with the aim of liberating the gastric mucosa from the end of the nasogastric tube.
If this failed, the patient was turned onto the left side for ten minutes if possible. In cases
where none of the above mentioned measures led to the obtaining of an aspirate, it was
decided to wait for a minimum of one hour and to re-aspirate again. Before any initial
administration of fluids, feeding or medication through the nasogastric tube a control x-ray
was performed, except in those patients who had pulled out the tube or who could not be
transported to the radiology department. With a pH result of ≥ 6, an X-ray control was
always performed (see figure 1). It was also documented if patients, at the time of placement
of the nasogastric tube, were taking antacids (proton pump inhibitors or H₂ receptor
antagonists).

(Figure 1)
2.3 Statistical analysis

Descriptive statistics were used to express means, standard deviations, percentages and frequencies. The Chi-squared test was used to compare discontinuous variables and the Mann-Whitney U for continuous variables. A significance level of $P < 0.05$ was used. A statistical programme (IBM, SPSS Statistics version 21®) was used to analyse the results.

3. Results

3.1 Study Population

The study included 331 patients. An x-ray was obtained in 301 patients. A pH measurement was performed in 272 patients. The average age of the participants was 69 years (18-94). Most participants were admitted to the Intensive Care Unit and Neurology department (see table 1).

(Tabel 1)

3.2 Obtaining an aspirate from the nasogastric tube

In almost half of all patients (48.6%) an aspirate was obtained immediately after intubation. The additional measures used (including the aspiration of air into the tube, side-positioning of the patient and re-aspiration after an hour) increased the success rate by 33.5% leading to an aspirate being obtained approximately for 4 out of 5 nasogastric tubes (82.2%) (see figure 2).

In a subgroup of patients (n=83) who were not indicated as nil by mouth, it was possible to obtain an aspirate in 96.4% of cases. For patients who were indicated as nil by mouth this was 77.3% (n=172) ($p< 0.05$). In patients with larger feeding tubes (C14) immediate aspiration was approximately 20% less successful than in patients with smaller tubes (CH10) respectively 35.5% versus 55.2% but more patients with a lager tube were on nil by mouth before placement (80.5% versus 61.8%).
3.3 Use of gastric antacids

About 2 of every 3 patients (67.7%) were taking antacids (H$_2$ receptor antagonists or proton pump inhibitors). Especially in Intensive Care, Nephrology and Surgery the use of these drugs was high, respectively 84.1% (n=89), 80% (n=12) and 78.8% (n=26). pH measurements for those patients with or without the use of antacids are illustrated in figure 3.

Without the use of antacids the average pH was found to be 3.5 (SD: 1.8), with use of antacids the average was 4.6 (SD: 1.7) (p<0.05). Analysis showed that 71% (n=76) of the pH measurements without antacids were below the pH cut-off point of ≤ 5.5 as opposed to 58.9% of those with antacids (n=132) (p=0.06). In 18.7% of total measurements (n=62) the pH was ≥ 6.

3.4 pH measurement versus radiological control

It was possible to obtain an aspirate from the nasogastric tube in 272 of 331 patients. However, as previously indicated in the research method, a number of patients (n=30) had pulled out their NG tube or were not deemed fit enough to be transferred to radiology. That left a total of 242 cases in which the aspirate could be compared to the x-ray results. One hundred eighty of these pH measurements showed a pH ≤ 5.5. With this cut-off point, the probability that the NG tube had been correctly placed in the stomach was 98.9% (positive predictive value). Two measurements showed a false positive test (pH ≤ 5.5) with placement in the distal oesophagus (two different intubations on the same patient). The low pH measured in this patient was the result of the existence of a large hiatal hernia. The remaining sixty-two pH measurements showed a pH ≥ 6. Of these, 49 were placed in the stomach and 12 were placed outside the stomach (see table 2). At a pH ≥ 6, the probability that the tip of
the NG tube was located outside the stomach was 24% (negative predictive value). The results of all pH measurements showed a sensitivity (the probability that the test correctly showed that the NG tube had been placed in the stomach) of 78.4% with a specificity (the probability that the test correctly showed that the NG tube was not in the stomach) of 85.7%.

(Table 2)

With a pH ≥ 6 from a NG tube that was correctly positioned in the stomach (n = 49), the characteristics of the aspirate were documented to aid explanation. Following aspects were observed: off-white/containing sputum (n=16), dark green (n=10), food-containing (n=9), dark brown (n=7), yellow (n=3), colourless (n=3), grassy green (n=1). In those cases where no aspirate could be obtained (n=60), 73.3% (n=44) of the NG tubes were found to be located in the stomach, the remaining 16 were located outside the stomach.

3.5 Auscultation versus radiological control

For all x-ray controlled NG tubes (n=301) the auscultation method could be applied and compared (see table 2). Using the auscultation method, the probability that the NG tube had been correctly placed in the stomach was 94.2% (positive predictive value). The probability that the absence of bubbling sounds indicated that the NG tube had been positioned outside the stomach (negative predictive value) was 29.3%. The results of the auscultation method indicate a sensitivity (the probability that the test correctly determines the gastric position of the NG tube) of 88.5% and a specificity (the probability that the test correctly indicates when the NG tube is not placed in the stomach) of 46.2%. Two cases of misplacement in the lungs (both on the same patient) were associated with an inconclusive auscultation and an inability to obtain a pH measurement (see figure 5). The patient in question appeared perfectly lucid and showed no signs or symptoms of respiratory distress or coughing. Without x-ray control this could potentially have led to food infusion into the patient’s lungs.
Another case involved a NG tube being placed in a comatose patient. Upon auscultation, the assisting nurse seemed certain that the NG tube had been placed correctly. The advanced practice nurse disagreed. It was not possible to obtain an aspirate. An x-ray showed the NG tube to be completely curled up in the patient’s throat. Ultimately, no feeding was started as the incorrectly positioned NG tube was pulled out and not immediately replaced. The patient died the following night of suspected cardiac complications.

4. Discussion

There are several studies available in the literature in which one or more test methods were used to determine the position of the NG tube in the stomach, the small bowel or the airways. In all of these, an x-ray or fluoroscopy was used as a control. In their review on studies using pH measurement to determine correct positioning of the NG tube in the stomach, Fernandez et al. found one study (n=134; 365 assessments) using pH 4 as cut-off point. With this cut-off point only 56% of the NG tubes were correctly determined to be in the stomach. The same study also used the auscultation method. This identified 84% of the correctly placed NG tubes but only detected 27% of the misplaced NG tubes. In another study in 280 intensive care patients, at pH < 4, the sensitivity was 49% and the specificity 74%. The auscultation method in this study showed a sensitivity of 96% and a specificity of 17%. Using a higher cut-off point of pH < 5, a more recent smaller study in 44 intensive care patients showed 90.4% of the NG tubes to be correctly identified in the stomach. A pH cut-off point of ≤ 5.5 was used in a study (n=247) that aimed to use the pH measurement to differentiate gastric positioning and small intestinal positioning of the NG tube Sensitivity in this study was 89% and specificity 87%. An identical pH cut-off point was used in two other studies to differentiate between gastric and small intestinal positioning. These studies however used pH measurements (n=1443) combined with bilirubin measurements from aspirates (< 5mg/dL). Pooled sensitivity in this study was 88% and specificity 99%.
According to our data, the current study is the first large scale study in adult hospital patients using the pH method (with testing strips) with a pH cut-off point of ≤ 5.5 to determine whether a NG tube has been successfully placed in the stomach. All NG tubes were controlled for correct positioning, immediately after placement and before first use. To limit as much as possible placement bias (for example differences in tube length measurement and/or intubation technique) and interobserver variability in the auscultation and/or pH method, all NG tubes were placed, or the placement supervised, by the same advanced practice nurse. A new aspect was also the simultaneous testing of different methods to evaluate the practical use of pH measurements. As pH measurement is an easy and reliable method to determine correct location of the NG tube in the stomach, an additional strength of this study were that several measures were taken to increase the number of aspirates. These measures can be easily used in daily practice and should be included in guidelines. While performing the study, the involved nurses were trained and taught: in this way the study promoted a correct intubation protocol. Although the use of antacids seems to have little influence on the reliability of ≤ 5.5 as a cutoff point for correct location of the NG tube in the stomach, approximately 40% of the measurements with antacids were ≥ 6. Per protocol this resulted in more abdominal x-rays. Also interesting to notice is that when an aspirate couldn’t be obtained (n=60) almost one of four tubes were located outside the stomach.

This study does have some limitations. Intubation by, or in the presence of, the same practitioner does not completely reflect current daily practice. We could have designed the study to allow department nurses to place the NG tubes and perform subsequent tests without direct supervision. This however would have required an in depth knowledge and uniform performance of the procedure by many nursing staff, which, at the start of the study, was not the case. With regard to measurement of the insertion-length of the tube, research indicates that using the NEX method, does maybe not always lead to correct tube lengths which can
alter aspiration from the tube. The principle of the NEX-method was first described in an old study in 30 premature infants and later extrapolated to adults and further cited in many nursing textbooks. A better alternative could have been to use a conversion chart to determine the real required length.

5. Conclusions

An aspirate pH of ≤ 5.5 appears to reliably reflect correct gastric positioning of the NG tube, even if antacids are used. However there is a small chance that the tube is positioned in the oesophagus. This method also has a good sensitivity and specificity. Extra measures can significantly increase the success rate for obtaining an aspirate from the NG tube. In cases of doubt, when obtaining an aspirate is not possible and in cases of a pH ≥ 6, a control x-ray should be performed. Even though the auscultation method allows for good assessment of gastric placement, the use of this method should be discouraged as it does not reliably allow for detection of the NG tube outside the stomach (low specificity). Besides the advantages of less discomfort and less subjection to radiation for the patient, standardised use of the pH measurement as the primary bedside test method can prevent NG tubes ending up in the wrong locations.

Statement of authorship

All authors state that they have made substantial contributions and final approval of the conceptions, drafting and final version of the manuscript.

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No funding.
Conflict of interest

We have no conflict of interest to declare.

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References


Figure 1: Protocol for determining the tip position of the tube
Figure 2: Obtaining an aspirate from the tube
Figure 3: pH-measurements (n = 272) with and without antacids
Table 1: Characteristics of study patients

<table>
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<th>Number of Patients</th>
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<tr>
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<tr>
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Charriere feeding

tube

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<td>CH 14</td>
<td>110</td>
<td>33.2</td>
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Swallowing

disorders | 186 | 56.2 |

X-ray | 301 | 90.9 |
Table 2: Radiological position of the tubes and results of pH-measurement and auscultatory method

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<tr>
<th></th>
<th>Stomach</th>
<th>Oesophagus</th>
<th>Lung</th>
<th>Duodenum</th>
<th>Throat</th>
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<td>(1.1)</td>
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<td>n=49</td>
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<td>2</td>
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<td>(15)</td>
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<td>(1.7)</td>
<td>(8.3)</td>
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<td>6</td>
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<td>(9.1)</td>
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Figure 1: Protocol for determining the tip position of the tube

Figure 2: Obtaining an aspirate from the tube

Figure 3: pH-measurements (n = 272) with and without antacids

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