Nurse performed ultrasonography in confirming the position of nasogastric tube in the Emergency Department

A prospective single group diagnostic test study

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Background
Nurses’ responsibility in verifying correct NG tube placement

Elderly woman dies in Hong Kong hospital after feeding tube is mistakenly inserted into her lung

A spokesman for expressed regret for the woman’s death.
Background
Nurses’ responsibility in verifying correct NG tube placement

• After insertion
• Right before feeding
• Suspected malposition

In AED

Often NG tube dislodgements require re-insertion.

Long stay require feeding

Present SOB with Hx of choking during feeding
Background
Limitation of conventional methods

pH test of aspirates

Auscultation Test

X-Ray verification

(HA Standard of practice, 2006)
Background
Limitation of pH test – Low sensitivity

- Acid-lowering medication (e.g. H2 blockers)
- Recently ingested food
- Alkali poisoned

False Negative

Fail to aspirate gastric content for pH test
21.3% patients whose gastric content were not able to be aspirated (Kim et al., 2012).
Background
Limitation of Auscultation test – not have sufficient specificity

- **Small-bore NG tube** may not allow sufficient passage of the air

- **Air-bubbling in the pleura, lung or esophagus** (kim et al., 2012).

  False Positive
Background
Limitation of X-Ray determination

Routine use of X-Ray is not practical
• Exposure to radiation
• Time and cost consumed
• Transporting manpower consumed

Any other option in verifying NG tube placement?
Background

Study purpose

Related foreign studies conducted in emergency center, ICU and prehospital settings (Kim et al., 2012, Chenaitia et al., 2012, Vigneau et al., 2005)

Ultrasonography is useful for verifying gastric tube placement.
Validation of nurse-performed FAST ultrasound

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ABSTRACT
Background: Nurses are routinely asked to perform FAST (Focused Assessment with Sonography for Trauma), therefore adequate training is essential. The aim of this study was to evaluate the ability of emergency nurses to detect simulated long bone fractures with portable ultrasound.

The ability of emergency nurses to detect simulated long bone fractures with portable ultrasound

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Abstract

Objective: The ability of emergency nurses (ENs) to perform ultrasound (US) for peripheral intravenous (IV) lines is unknown. We compared nurses’ success rate to that of emergency physicians.

Methods: This was a prospective observational study of ENs placed IV lines in a local emergency department (ED) for patients presenting to the ED. We compared ENs’ success rate to that of emergency physicians (EPs).

Results: There were 29 ENs and 38 EPs who attempted to place IV lines. The success rate for ENs was 86% (25/29) compared to 97% (37/38) for EPs. The failure rate for ENs was 14% (4/29) compared to 3% (1/38) for EPs.

Conclusion: ENs are able to successfully place IV lines in the ED, but they have a lower success rate compared to EPs.

Emergency Nurses’ Utilization of Ultrasound Guidance for Placement of Peripheral Intravenous Lines in Difficult-access Patients

Larry Brannam, MD, RDMS, Michael Blaivas, MD, RDMS, Matthew Lyon, MD, RDMS, Michael Flack, RN

Abstract

Objectives: Emergency nurses (ENs) typically place peripheral intravenous (IV) lines, but it is not known if ENs have the same success rate as emergency physicians (EPs). The purpose of this study was to compare the success rate of ENs and EPs in placing IV lines.

Methods: This was a prospective observational study of ENs and EPs who attempted to place IV lines in a local emergency department (ED) for patients presenting to the ED. ENs and EPs were asked to provide demographic information and answer questions related to their experience with IV line placement.

Results: There were 29 ENs and 38 EPs who attempted to place IV lines. The success rate for ENs was 86% (25/29) compared to 97% (37/38) for EPs. The failure rate for ENs was 14% (4/29) compared to 3% (1/38) for EPs.

Conclusion: ENs are able to successfully place IV lines in the ED, but they have a lower success rate compared to EPs.
Background
Potential Benefit to patient, department & nursing
Scanty data in local AED

Lack of validation of nurse performed ultrasonography in Hong Kong

Nurse performed ultrasonography in confirming the position of nasogastric tube in the Emergency Department
Research Design

- Quantitative
- Prospective
- Cross-sectional
- Single Group Diagnostic test
  - One specific group of subjects: Patients with nasogastric tube.
- Single - blinded
  - Investigators are “blinded” from the position of the nasogastric tube
Research Strategy

PICO

- A framework for formulating research question
- A strategy for choosing research methodology

<table>
<thead>
<tr>
<th>P</th>
<th>I</th>
<th>C</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Patient Problem</td>
<td>Intervention Or Exposure</td>
<td>Comparison</td>
<td>Outcome</td>
</tr>
<tr>
<td>Who are the patients?</td>
<td>What do we do to them?</td>
<td>What do we compare the intervention with?</td>
<td>What happens?</td>
</tr>
<tr>
<td>What is the problem?</td>
<td>What are they exposed to?</td>
<td></td>
<td>What is the outcome?</td>
</tr>
</tbody>
</table>

(Sackett et al, 1997)
**Patient**

● **Inclusion criteria:**
  ✓ Age ≥ 18
  ✓ Patient / Legal Guardian able to read Chinese / English
  ✓ **Patients with nasogastric tube** and require Chest x-ray / Abdominal x-ray or
  ✓ **Patients require Chest / Abdominal x-ray** after insertion of nasogastric tube
  ✓ Recruited from the AED of three local hospitals (QEH, TKOH, YCH)
  ✓ Consecutive convenience sampling (Subjects were recruited when investigators on duty)
Patient

Exclusion criteria:

- Patient with unstable hemodynamic status
- Known history of nasopharyngeal carcinoma
- Known history of fracture base of skull
- Known history of surgical problems of the pharynx, larynx, trachea, esophagus or stomach
- Patients with tracheostomy
- Patients with Aortic Aneurysm
- Pregnancy
Intervention

- Nurse performed bedside ultrasonography scan to confirm the position of nasogastric tube
Interventions
Ultrasonography tests

1. **Neck Scan:**
   - Acoustic Shadow over the esophagus region

2. **Epigastrium Scan:**
   - Acoustic shadow in epigastric region

3. **Air Injection test**
   - Hyperechogenic “foggng” in stomach by injecting air via the NG tube

(Kim et al., 2012)
Interventions
Ultrasonography tests

- Neck Scan – Transverse Scan:

  Normal esophagus

  Esophagus with NG tube
Interventions
Ultrasonography tests

- Neck Scan – Longitudinal Scan:

![Ultrasound image of neck scan showing skin, trachea, and esophagus with NG tube.](image-url)
Interventions
Ultrasonography tests

- Epigastrium Scan – Transverse Scan:

Stomach
Acoustic shadow of NG tube
Interventions

Ultrasonography tests

- Hyperechogenic “fogging”:
Interventions
Ultrasonography tests

- Colour Doppler “fogging”:
Comparator

- Current Gold Standard of nasogastric tube placement confirmation:

Chest / Abdominal X-Ray

(HA Standard of practice, 2006)
Outcomes

- Dichotomous results:
  - Ultrasonography tests,
  - pH tests of Aspirates
  - “Whoosh” Test
  - X-Ray Evaluation

Positive
Negative
Sample Size Estimation

- Based on previous study (Kim, et al, 2012)
- Formula for estimate the sensitivity and specificity of single diagnostic test (Tilaki, 2014)

\[
n = \frac{Z^2_{\frac{1}{2}} \hat{p}(1 - \hat{p})}{d^2}
\]

- Pre-determined value of specificity = 0.67
- Inserted by 1.96
- Maximum marginal error of estimate = 0.07
- level of significance = 0.05
- Power = 0.80

- Targeted number of samples = ~173 subjects
Data Collection
Bedside Ultrasonography Training for Investigators

Emergency Ultrasound Guidelines 2010
Data Collection
Bedside Ultrasonography Training for Investigators

Appendix 3: Training pathway & level of proficiency

- EM resident or practitioner
  - Basic USG course by HKCEM or equivalent
    - Basic EM USG Trainee
      - Scanning under supervision by EM USG independent practitioner
        - Meet the minimal no. of scanning with log record
          - Endorsed by Training supervisor
            - Independent EM USG Practitioner
              - Independent scanning for at least 6 months & nominated by training supervisor

(Emergency Ultrasound Guidelines 2010, HKCEM)
Data Collection

Bedside Ultrasonography Training for Investigators

- Half day workshop in QEH AED
- 23rd of January, 2015
- Guest lecturer and trainer:
  Dr. Pak Chi Shing
  Associate Consultant of QEH AED
  specialized in emergency ultrasonography
- Lecture and practical sections
- PowerPoint sharing
Data Collection
Bedside Ultrasonography Training for Investigators

- Bedside practice of essential skills for data collection
Data Collection
Bedside Ultrasonography Training for Investigators

➢ Assessment and Evaluation of skills

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*Image of a form for evaluating ultrasonography skills*
Data Collection
Study Protocol

Nurse performed ultrasonography in confirming the position of nasogastric tube

Medical Consultation

Patients with nasogastric tube and require Chest x-ray / Abdominal x-ray
or
Patients require Chest / Abdominal x-ray after insertion of nasogastric tube*

Chest / Abdominal X-ray

Patient fulfill inclusion criteria and consent obtained

Ultrasonography (Transversal / Longitudinal neck scan)

Ultrasonography (Transversal / Longitudinal abdominal scan)

Ultrasonography (Hyperechogenic / Colour Doppler “fogging” test *)

Aspirate pH test

Auscultation “Whoosh Test”*

Patient with Contraindication or refuse study

Discharge or Admission after consultation

Correct Position

Immediate Re-insertion of NGT

Incorrect Position

Evaluation of X-ray by physician not involved in the medical consultation +
Review of Ultrasound findings with medical personnel

Correction: * Reinsertion of the nasogastric tube if any signs and symptoms of bronchic insertion
* Auscultation of gurgling sound over the left upper quadrant of the abdomen by injecting air via the nasogastric tube.
* Visualization of hyperechogenic “fogging” by injecting 40ml of air through the nasogastric tube.
Data Collection
Self-developed Data Collection Sheet

Inclusion criteria
- Age ≥ 18
- Patients with nasogastric tube and require Chat x ray
- Abdominal x ray - Patients require Chat / Abdominal x ray after insertion of nasogastric tube
- If all “Yes”, proceed to checking for exclusion criteria.

Exclusion criteria
- Patients with unstable haemodynamic status
- Known history of neurological conditions
- Known history of fracture base of skull
- Known history of surgical problems of the pharynx, larynx, trachea, esophagus or stomach
- Patients with haemoptysis
- Patients with Aortic Anomaly
- Pregnancy
- Call “No”, proceed to study after patient’s consent.

Assessment Record

Part 1: pH test of Aspiration
- Positive
- pH of the aspirate: 2.4

Part 2: "Washout Test"
- Positive
- Administration of the epinephrine by injecting it through the nasogastric tube
Data Collection
Self-developed Data Collection Sheet

Part 3(b). Ultrasonography – Abdominal Scan

- Transverse scan
- Longitudinal scan

Please print out the image and attach to the data collection sheet.

Part 4. X-Ray evaluation

- Chest / Abdominal X-Ray

X-Ray reviewer should be medical personnel not involved in the medical consultation.

Name / Rank of X-Ray reviewer:

Name / Rank of USG reviewer:

Material of the nasogastric tube:

Name of investigator (s):

Note: The total volume of air injected should not exceed 40ml.
Data Collection
Self-developed Data Collection Sheet

- Assessment and Evaluation of skills (Minimum 5 positive scans)
Data Analysis

- SPSS ver.16
- Descriptive statistics:
  - Describe the characteristics
  - Frequency, mean and SD
- Inferential statistics:
  - Sensitivity
  - Specificity
  - Positive Predictive Value
  - Negative Predictive Value
  - Likelihood Ratios
Ethical Issues

• **Ethical Approval** from Clusters Research Ethical Committee

• **Informed written consent** (English / Chinese)
  • Obtained from Patient or
  • Obtained from patient’s legal guardian if mentally incompetent

• Voluntary basis
• Not affect standard treatment
• Right to terminate participation at any point
• Contact details of the investigators
• Anonymity
• Confidentiality
### Table 1. Characteristics of the subjects

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n = 72</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>min 61 / max 99</td>
</tr>
<tr>
<td></td>
<td>mean 84.76 ± 8.46^</td>
</tr>
<tr>
<td>Gender (male / female)</td>
<td>27 (37.5)^+ / 45 (62.5)^+</td>
</tr>
<tr>
<td>Currently using anti-gastric ulcer medications</td>
<td>59 (81.9)^+</td>
</tr>
<tr>
<td>Subjects with gastric aspirate NOT available</td>
<td>19 (26.4)^+</td>
</tr>
<tr>
<td>Material of NGT* (Silicon / Latex)</td>
<td>60 (83.3)^+ / 12 (16.7)^+</td>
</tr>
</tbody>
</table>

^Mean ± SD, SD: Standard Deviation
+Number (%)
*Nasogastric Tube
Results

Chart 1. Reasons of AED attendance (n=72)

- Dislodged NGT*: 3%
- Medical Problems: 18%
- Surgical Problems: 3%
- Others: 3%

* Nasogastric Tube
## Results

### Table 2. Comparison of predictive validity

<table>
<thead>
<tr>
<th>Evaluation method</th>
<th>Total (n=72)</th>
<th></th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>correct position (n=69)</td>
<td>incorrect position (n=3)</td>
<td>Estimate</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Ultrasound</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>(+)</td>
<td>66</td>
<td>0</td>
<td>95.7</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>3</td>
<td>3</td>
<td>52.2</td>
</tr>
<tr>
<td>Abdomen</td>
<td>(+)</td>
<td>36</td>
<td>0</td>
<td>88.4</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>33</td>
<td>3</td>
<td>89.9</td>
</tr>
<tr>
<td>Hyperechogenic “fogging”</td>
<td>(+)</td>
<td>61</td>
<td>0</td>
<td>91.3</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>8</td>
<td>3</td>
<td>55.1</td>
</tr>
<tr>
<td>Colour Doppler test</td>
<td>(+)</td>
<td>62</td>
<td>0</td>
<td>88.4</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>7</td>
<td>3</td>
<td>89.9</td>
</tr>
<tr>
<td>‘Whoosh’ test</td>
<td>(+)</td>
<td>63</td>
<td>0</td>
<td>91.3</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>6</td>
<td>3</td>
<td>55.1</td>
</tr>
<tr>
<td>pH test of aspirates</td>
<td>(+)</td>
<td>38</td>
<td>0</td>
<td>88.4</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>31</td>
<td>3</td>
<td>89.9</td>
</tr>
</tbody>
</table>
Table 3. Comparison of predictive validity

<table>
<thead>
<tr>
<th>Evaluation method</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>LR+</th>
<th>LR-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>95% CI</td>
<td>Estimate</td>
<td>95% CI</td>
</tr>
<tr>
<td>Ultrasound</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>100</td>
<td>94.6 to 100</td>
<td>50</td>
<td>11.8 to 88.2</td>
</tr>
<tr>
<td>Abdomen</td>
<td>100</td>
<td>90.3 to 100</td>
<td>8.3</td>
<td>1.8 to 22.5</td>
</tr>
<tr>
<td>Hyperechogenic “fogging”</td>
<td>100</td>
<td>94.1 to 100</td>
<td>27.3</td>
<td>6.0 to 61.0</td>
</tr>
<tr>
<td>Colour Doppler test</td>
<td>100</td>
<td>94.2 to 100</td>
<td>30</td>
<td>6.7 to 65.3</td>
</tr>
<tr>
<td>‘Whoosh’ test</td>
<td>100</td>
<td>94.3 to 100</td>
<td>33.3</td>
<td>7.5 to 70.1</td>
</tr>
<tr>
<td>pH test of aspirates</td>
<td>100</td>
<td>90.8 to 100</td>
<td>8.8</td>
<td>1.9 to 23.7</td>
</tr>
</tbody>
</table>

PPV: positive predictive value  /  NPV: negative predictive value  /  LR+: Positive likelihood ratio  /  LR-: Negative likelihood ratio
Discussion

• A **high sensitivity and specificity** of using ultrasonography in confirming the position of NGT

• Performed by emergency nurses with **specific training and practice.**

• **can be incorporated in daily practice** because …
Discussion

• To overcome limitations of Conventional Methods
• Immediate bedside confirmation

• pH test not recommended to be used alone for confirmation

“Whoosh test” & Bedside USG are recommended to be used for secondary confirmation of NGT position
Limitations

- **Limited time of data collection**
  - Limited number of subjects (Required: 173 vs Achieved: 72)
  - Subjects with in-correct NGT placement were scanty (n=3)

- **Limited number of study sites**
  - ? generalizability of the research findings

- **Accuracy of performing USG**
  - Variation in skills and experience of investigators
  - Gas interposition and involuntary movements of the patient

- **Spectrum Effect**
  - Uneven mix of study population affect prevalence of phenomenon
    (Correct position: 69 vs Incorrect position: 3)
• Longer study period is recommend in future studies

• Larger scale studies are required in the future

• Inter-rater reliability of nurse performed ultrasonography should be studied

• Validation of ultrasound training for nurses should be conducted

• More even mix of study population is recommended
Conclusion

• Nurse performed USG allow immediate bedside confirmation of nasogastric tube position
• Beneficial to patients, nursing and departmental operations
• Conventional tests still have their own limitations
• Bedside ultrasound provide extra evidence for clinical judgment
• Nurse performed USG can be incorporated into daily practice for confirmation of NGT position
• X-ray is still recommended if bedside USG failed to confirm the position of NGT
Acknowledgement

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Thank you very much!