Final Report
University of Michigan
Industrial and Operations Engineering
Hospital Systems
Professor Richard Coffey

Submitted to:
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Submitted by:
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December 17, 1997
Executive Summary

The PICU began using the pH-sensing feeding tubes in July of 1997. Also at this time, the nurses underwent training and began placing the pH-sensing tubes instead of the physicians. The use of the air injection technique began at this time as well. In September 1997 this project began by the request of Cathy Ricciuti, Product Liaison, Material Services. She asked that a study be done on the new pH-sensing tubes. The purpose of the project was to determine if the pH-sensing feeding tube is more cost effective.

Through discussions with the client, Cathy Ricciuti and the project coordinator, Professor Richard Coffey, the project was defined. We learned medical terms and the process of feeding tube placement through interviews with the clinicians in the PICU. We then flowcharted the process. To gather data, we collected and analyzed pH feeding tube trial charts and conducted and administered a survey. Benefits and costs of using the pH-sensing and standard feeding tubes were identified. Findings and recommendations were made.

Throughout the project, a number of problems were encountered. We had originally planned to do a retrospective study comparing the success rates of the pH-sensing tubes and the standard feeding tubes. We had hoped this information would be available in medical records. However, patient’s medical records were difficult to understand and information of feeding tubes was hard to find. We then went to radiology records to find how many confirmation x-rays were taken for PICU patients, so as to determine the number of attempts it took to successfully place a feeding tube. Another problem encountered was the lack of cooperation of the PICU. Numerous requests were made for clinicians to continue to fill out pH feeding tube trial sheets, and this was not done. Also, numerous phone calls requesting interviews and a response were not returned. This provided a major hindrance to the project.

The protocol for tube placement is as follows: measure and mark on feeding tube the distance from nose to ear, ear to navel, and add 10 cm; insert tube into nose; one the tube is in the stomach, inject air; advance tube into duodenum. See appendices A and B for flow charts detailing the process flow.

Based on the pH feeding tube trial forms, the success rate of placing the pH-sensing feeding tube on the 1st attempt in the duodenum is 37.5%, in the stomach or duodenum is 62.5%. Based on the survey, the success rate in placing the pH-sensing feeding tube in the duodenum is 42.85% and in the stomach is 100%. The survey also indicated that the success rate in placing the standard tube in the duodenum is 52.16% and in the stomach is 100%. According to the survey and informal interviews, most nurses were indifferent to the pH-sensing feeding tube. We also found that there was a lack of communication and understanding which may cause a decrease in the success rate of placement. One clinician that was interviewed said that pH-sensing tubes were sometimes placed after a patient was given acidic medication, making it ineffective. If she had been properly
informed that the acidic medication could be neutralized with saline solution which would have aided in the correct placement of the tube. Another finding we had was that in November 1997, the placement of the standard tubes by the physicians was unsuccessful. However, this may have been because air injection was not used and physicians had not placed tubes since June 1997.

In conclusion, we find that the pH-sensing feeding tube is not more cost effective than the standard feeding tube. We recommend that the use of pH-sensing feeding tubes be discontinued. We also feel that the air injection technique should continue being used. Communications between clinicians should be improved and the differences in the placement protocol between Peds Meds and Peds Surgery should be investigated.
INTRODUCTION AND BACKGROUND

The patients' nutritional needs are a vital part of hospital care. At times when patients are unable to feed themselves or have others feed them, the placement of transpyloric feeding tubes become necessary. Transpyloric feeding tubes allow patients to receive nutrition directly into the duodenum. This is accomplished by placing a feeding tube through one of the patient's nasal canals and into the duodenum. Since transpyloric feeding tubes play an extremely important part in patient nutrition, a strong emphasis is placed on its use.

Placing transpyloric feeding tubes can be both, time consuming and costly. After a feeding tube is placed it is necessary to confirm that the tube is in the duodenum. Misplacement of feeding tubes could endanger the health of the patient and possibly result in death. The only way to ensure proper placement is to have the patient take a confirmation x-ray. The confirmation x-ray allows the physician to determine if the tube is in the duodenum. If the feeding tube has not been correctly placed into the duodenum the first time, the tube must be removed and placed again, and another confirmation x-ray must be taken. The patient undergoes this procedure until the tube is correctly placed in the duodenum. The current protocol of the University of Michigan Hospitals is to have a maximum of three, confirmation x-rays be taken before the patient undergoes an expensive fluoroscopy x-ray. While a feeding tube is relatively inexpensive the costs begin to accumulate when multiple x-rays are required.

In July of 1997, the Pediatric Intensive Care Unit (PICU) incorporated the use of pH sensors in the placement of transpyloric feeding tubes. The pH sensing feeding tubes allow the clinicians to determine the pH of the area where the tube was placed. Since the pH of the duodenum differs from the surrounding organs it was believed that the sensor would help the clinicians in transpyloric feeding tube placement. Although the pH sensing feeding tubes are expensive, if the tubes could be correctly placed the first time it would reduce the number of additional x-rays.

At the end of November 1997, possibly sooner the PICU has to order additional pH sensing feeding tubes. Presently, the Material Services Department is uncertain about the cost effectiveness of the pH sensing feeding tubes in comparison to the placement of traditional feeding tubes. Material Services would like to conduct an unbiased study on the effectiveness of the pH sensing feeding tubes. They have requested the aid of Industrial and Operations Engineering (IOE) students to conduct this study. The results attained from this study will help Material Services determine which method is more cost effective and if they should order additional pH sensing feeding tubes for the PICU.
APPROACH AND METHODOLOGY

The purpose of the project was to conduct a cost effectiveness evaluation of the pH sensing feeding tubes versus the traditional feeding tube. The approach most suitable for this type of evaluation was a cost analysis of the two feeding tubes. The cost analysis conducted analyzed both the direct and indirect costs related to the placement of either feeding tubes.

The following was the methodology taken to conduct the cost analysis:

*These were the planned steps to be taken at the start of the project but do not reflect the difficulties encountered and changes made by the project team. Difficulties and changes are elaborated on in the next two section.

1. **Identify PICU tube fed patients spanning back to February 1997.**
   A list of tube fed patients in the PICU and their registration numbers were obtained from Ron Dechert of Critical Care Support Services. The list allowed Medical Records to retrieve the records for study.

2. **Separate patients into two groups:**
   - **Study Group:** patients whose feeding tube was placed using a traditional feeding tube.
   - **Control Group:** patients whose feeding tube was placed using a pH sensing feeding tube.

   After Medical Records retrieved the requested records we had planned to analyze the charts to determine which patients received the traditional feeding tubes and which patients received the pH sensing feeding tubes, and whether or not the placement was successful.

3. **Flowchart processes.**
   The use of feeding tubes were observed from the initial order until the confirmation of placement. Flow charts were made for traditional feeding tubes and pH sensing feeding tube. See Appendix A and B.

4. **Identify all costs.**
   The flow charts were carefully analyzed to locate all steps where costs where incurred. Examples would be, the costs of the tubes, cost of confirmation x-rays, cost of fluoroscopy x-rays, and the cost of the clinician’s time to accompany a patient to fluoroscopy. The Finance and Motts Radiology departments of the University of Michigan Hospitals was contacted to attain the TSI costs related to such examples. See Appendix C.

5. **Identify outcomes.**
   The charts were analyzed to determine the success of both the traditional and pH sensing feeding tubes.

6. **Compare results.**
   Take the success rates found from the records and costs related for both and compare to determine which feeding tube would be most cost effective. Answer the following questions:
   - Are the higher cost of the pH sensing feeding tubes justified?
   - Does the pH sensing feeding tube provide a higher success rate in placement?
PROBLEMS ENCOUNTERED

Minor problems were encountered along the way such as miscommunication, scheduling difficulties, hospital bureaucracy, and comprehension of medical terms. These problems were handled and did not pose a serve hindrance to the completion of the project. Two major problems encountered which did pose severe hindrance were cooperation of PICU and contents of medical records.

The staff of the PICU are constantly busy and on the move, occupied with the important task of helping critically ill children recover. It was extremely difficult to attain their cooperation during their work shifts. Some staff of the PICU were contacted numerous times without a response. The project team were only able to have clinicians answer questions in between shifts or following the clinicians until they were available. However, we would like to acknowledge the tremendous amount of assistance and cooperation provided to the project team by the Material Services Department, particularly the client, Cathy Riccuti.

The contents of medical records or lack of contents proved to be a major problem. In the original methodology we had planned to assemble patient records spanning back to February 1997. These records would have then been divided into two groups. A control group consisting of patients which had traditional tube placement and a study group consisting of patients with pH sensing tube placement. After the patient records were separated, each file was reviewed to determine the success rate. When we began reviewing each record, we realized that procedures were not fully documented. Generally a request for a feeding tube was made and the next medical entry noted that a feeding tube had been placed. The number of attempts were not cited, and difficulties were not documented. Also the number of confirmation x-rays were not specified. This led to significant restructuring of our research approach. Changes made are documented in the following section, Restructuring.

RESTRUCTURING

Our first attempt to supplement the lack of information in patient records was to have the clinicians document recent attempts at tube placement. A form, pH Feeding Tube Trial (See Appendix D) was created by Cathy Riccuti in July for the clinicians to fill out. The information on the forms would provide us the necessary data to determine success rates. However, only 8 forms were filled out by the PICU clinicians. This relates back to the cooperation difficulties we encountered. The results are quantified in the following table.

<table>
<thead>
<tr>
<th>pH-Sensing Feeding Tube</th>
<th>Success Rate</th>
<th>n=8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st attempt</td>
<td>37.5 %</td>
<td></td>
</tr>
<tr>
<td>2nd attempt</td>
<td>20.0 %</td>
<td></td>
</tr>
<tr>
<td>No 3rd attempts were made</td>
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</table>
Another attempt to clarify the vague patient records was to contact the Radiology Department. We were informed that Radiology maintained records of each x-ray performed, which included confirmation x-rays. Although this expanded the research scope of the project, it was a necessary step to supplement the lack of information in patient records. We then searched through Radiology’s records on the PICU patients in our study. Unfortunately, Radiology’s records did not provide us with the information we needed. Vague references and notes were made regarding tube placement. X-rays were often not taken specifically to check feeding tube placement. This made it difficult to determine which x-rays were used for what, since the location of the feeding tubes is always recorded in the x-rays. Again we were faced with insufficient data.

We then researched medical journals at the Taubman Medical Library regarding pH-sensing feeding tubes. We were only able to find one journal which applied to our situation, tube placement in children. The journal, “Rapid Placement of Transpyloric Feeding Tubes: A Comparison of pH-assisted and Standard Insertion Techniques in Children” was a prospective study held at the Children’s Hospital Medical Center in Cincinnati. This hospital is comparable to the PICU in Mott’s Children’s Hospital. The journal is an advocate for the pH-sensing feeding tube. Although the journal was an advocate for the pH-sensing feeding tube their were several questionable issues regarding the journal. The primary issue was that it was sponsored by the company which develops and markets the pH-sensing feeding tube. Secondly, it was the only journal available that addressed the success of pH-sensing feeding tube in children. If a non-biased study was held and/or more studies were available would provide more reliable information. Simply relying on one study sponsored by the makers of the product would be a questionable step.

Informal interviews of PICU clinicians were also held to attain their attitudes towards the pH-sensing feeding tubes and determine the success they have had. The general reactions were indifference towards the pH-sensing tube. From their own experiences many did not feel their success with pH-sensing tube were significantly better, many felt that the pH-sensing tube was just as good to the dobbhoff.

Surveys were distributed to the clinicians in the PICU in order to document their views and personal experiences with feeding tube placement. Although there were few responses (8) they did further support the indifference towards the pH-sensing tube. A copy of the survey is included in Appendix E. The results are discussed in the findings.

**PROCESS FLOW**

Patients that come to the PICU are critically ill, in need of constant care and supervision. These patients are usually sent from surgery, the emergency room, or their doctor. There are a wide variety of patients in the PICU. Their problems vary from respiratory to neurological problems. Some patients go to the PICU to recover from surgery or a transplant.
Once a child arrives in the PICU, the staff attempts to improve the health of the patient by acting as a catalyst to their recovery. An essential part of a patient’s recovery is the nutrition he/she receives. In order for the healing process to start, the body must have a fuel that provides the energy needed. The most common way people receive this fuel is through eating food. However, most patients in the PICU are unable to eat. Their bodies are too weak to process whole foods. Therefore, their nutrients must be provided in an alternate way. One way is through an intravenous tube (IV) which provides some, but not all nutrients directly into the bloodstream through a vein. Another method is through a transpyloric feeding tube, a tube that is sent through the nose, esophagus, stomach and into the small intestines. The feeding tube is a much better alternative because it provides total nutrition directly into the small intestines.

When the doctor determines that the patient should begin tube feeding, he/she issues a written or verbal order for the placement of a feeding tube and the feeding of certain nutrients. Presently, in the PICU, the clinician takes the order and places a pH sensing feeding tube. The protocol for tube placement is as follows:

- Using the feeding tube, measure from nose to ear, ear to navel and add 10cm mark this distance on the tube.
- Insert feeding tube through nose.
- When the feeding tube reaches the stomach, (approximately 10cm before the mark on the tube) inject air into the stomach. (Note: the amount of air injected depends on the size of the patient)
- Turn the patient on his/her side and insert the feeding tube the remainder of the way.

When the clinician feels that the tube has reached the duodenum, a portable chest x-ray is taken to confirm the placement of the feeding tube. If the tip of the feeding tube is located in the duodenum, feeding is begun immediately. If the tip is in the stomach and the patient is a Peds Surgery patient, feeding is begun. If the tip is in the stomach in a Peds Meds patient, the tube is taken out and placed again. If the tip of the feeding tube is in neither the stomach nor the duodenum, the tube is removed and attempted to be placed again. If the clinician is unsuccessful in placing the tube after three attempts, the patient is usually sent to fluoroscopy. An exception to this standard is when a patient is too sick to be transported to radiology. In this case, it is up to the physician to decide whether to take that risk, or to begin feeding into the stomach (assuming the tube was placed in the stomach on the third attempt) and hope that the patient does not aspirate.

Prior to July 1997, the protocol was different in that a standard dobbhoff feeding tube was used, instead of a pH sensing. Also, before July, only physicians were permitted to place feeding tubes. When the PICU began using pH sensing feeding tubes, the nurses were trained to place them. Although the nurses were allowed to place the pH sensing tubes, they were not allowed to place dobbhoffs until November 1997.
FINDINGS AND CONCLUSION

Air injection was found to be an important factor in the success of the feeding tube placement. Without air injection, the success rate for placement was low, but with air injection, the success rate was much higher.

An inconsistent protocol exists between the Peds Meds and the Peds Surgery. While both would ideally like the feeding tube to be placed in the duodenum, Peds Surgery accepts placement in the stomach while Peds Meds requires placement in the duodenum before feeding begins. Peds Surgery feels that it is more important to begin feeding as soon as possible than to place the feeding tube in the duodenum.

A lack of communication and understanding exists within the PICU staff. Some clinicians have placed a pH-sensing feeding tube after the patient received acidic medication, making the pH-sensor ineffective.

The surveys and informal interviews indicate that most clinicians were indifferent to the pH-sensing feeding tubes. They felt that the pH-sensing tubes were just as good as the traditional tubes. A clinician who had never placed a feeding tube was instructed to place a standard tube. After having placed the tube successfully on her first attempt, she said that she found it very easy and that she really did not need a pH-sensing feeding tube. She said that she could tell where the feeding tube was by how far she had inserted it. Another clinician said that he could tell if he was going towards the intestines by the sounds he heard in the stomach. Also, based on the pH Feeding Tube Trial forms and surveys we were able to determine a success rate for pH-sensing feeding tube placement in the PICU.

Based on the pH Feeding Tube Trial forms the success rate for placing the pH-sensing feeding tube on the first attempt in the duodenum is 37.5%. Placing in the stomach or the duodenum is 62.5%. Based on the surveys the success rate in placing the pH-sensing in the duodenum is 42.85% and in the stomach is 100%. The success rate in placing the traditional tube is 52.16% and in the stomach 100%. One obvious point this data indicates is that there is very good success in placement in the stomach. It is important to note here that the sample size of the pH Feeding Tube trial was 8 while the sample size for the survey was 9 and they were all clinicians. It is also important to note that air injection was not used in some of the pH-sensing tube placements which may have been a cause for the lack of success. Also, three of the subjects who filled out the survey had never placed a standard tube, making the sample size for the standard tubes even smaller. Most of the clinicians who filled out the survey, have only placed a few pH-sensing feeding tubes because it wasn’t until July that they were allowed to place them.

Both the survey and the forms show that placing a feeding tube in the stomach has a high success rate. But, the success rate for placement in the duodenum is higher for the standard feeding tube.
Based on the above findings, we conclude that the use of the pH-sensing feeding tube in the PICU is not cost effective in comparison to using the standard feeding tube. It is also concluded that air injection played an important role in the success rate of tube placement.

RECOMMENDATIONS

Based on our findings the following is a list of recommendations for the PICU:

1. Discontinue the use of the pH-sensing feeding tube and continue the use of standard feeding tubes.
We have not found enough evidence to justify the continuation of the pH-sensing feeding tubes. The data collected indicated that the placement of the standard feeding tube was just as good, if not better than the pH-sensing tube, making it more cost effective.

2. Continue the use of air injection in the protocol for feeding tube placement.
The air injection technique was found to be a large variable in the success of the placement. The first two placements of the pH-sensing feeding tube were unsuccessful while the third was successful. Air injection was only used in the third one. In November when the pH-sensing feeding tubes ran out, the physicians attempted to place the standard feeding tubes. According to one of the clinicians, they were unsuccessful in both of attempts. Air injection was not used. As mentioned in the previous section, a clinician, placing a feeding tube for her first time ever, placed a standard tube successfully on her first attempt. She used the air injection technique.

3. Standardize the placement protocol between Peds Meds and Peds Surgery.
The different protocols have led us to question which one is right. There may be very good reasons behind the different protocols, but we would simply like to raise the question.

4. Improve communication between clinicians regarding protocol and proper use of new equipment.
When you are in the business of saving lives it is vital to have excellent communication. In our interviews we discovered that the communication in the PICU needs improvement. In one meeting we noticed that not everyone had read the e-mail from the previous week which informed everyone that the clinicians were allowed to place the standard feeding tubes. Another example is that pH-sensing feeding tubes were placed after the patient was given acidic medication, it was not washed out with saline, so the pH-sensor was ineffective.
Appendix A
Patient → PICU, PODS B & C → Doctor orders tube feeding (verbal or written) → Clinician takes order

\[ x = 0 \]

Clinician places feeding tube \[ x = x + 1 \]

Chest x-ray taken to confirm correct placement

Placed in duodenum?

Yes → Begin feeding

No, \[ x < 3 \] → Patient sent to Fluoroscopy

No, \[ x = 3 \]

\[ x = \text{number of placement attempts} \]
Appendix B
Peds Surgery

Patient → PICU, PODS B & C → Doctor orders tube feeding (verbal or written) → Clinician takes order

$x = 0$

Clinician places feeding tube $x = x + 1$

Chest x-ray taken to confirm correct placement

Placed in duodenum or stomach?

Yes → Begin feeding

No, $x < 3$

No, $x = 3$

Patient sent to Fluoroscopy

$x = $ number of placement attempts
Appendix C

Costs:

Average standard feeding tube: $10

pH-sensing feeding tube: $42

Basic x-ray: $84 + $21 (for professional fee) = $105

Fluoroscopy: $399 + $63 (for professional fee) = $462

note:
The costs of the feeding tubes were obtained from the Material Services department. The information for the costs of the x-ray and fluoroscopy was obtained from Mott's radiology.
The purpose of this trial is to determine if feeding tubes placed with a pH monitor are more frequently successfully placed without fluoroscopy than feeding tubes placed without a pH monitor. Please complete all data points requested. If you have questions about use of the pH monitor and feeding tubes contact Rhonda Schoville at 6-8980, if you have questions about the trial in general contact Cathy Ricciuti at 6-6174.

<table>
<thead>
<tr>
<th>Patient's Name</th>
<th>Reg #</th>
<th>Trial #</th>
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<tbody>
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DOB _______ AGE _____ Sex M F Diagnoses ___________________________

Weight (kg): _______

<table>
<thead>
<tr>
<th>pH Readings</th>
<th>Esophagus</th>
<th>Stomach</th>
<th>Intestine</th>
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</thead>
<tbody>
<tr>
<td>1st Attempt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Attempt</td>
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</tbody>
</table>

Placement Attempts

<table>
<thead>
<tr>
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<th>X-ray Date/time</th>
<th>Success Yes/No</th>
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</thead>
<tbody>
<tr>
<td>1st Attempt</td>
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<td>2nd Attempt</td>
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<tr>
<td>3rd Attempt</td>
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</table>

Comments (Include outcome of procedure & specific patient issues):

Please list any adjunct therapies used to facilitate passage of the tube:

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapy 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therapy 2</td>
<td></td>
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<tr>
<td>Therapy 3</td>
<td></td>
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</tbody>
</table>

Name of clinician placing tube _______________________ Title ___________ Phone#_____

pHtube.xls
Appendix E
The purpose of this survey is to find out how the clinicians feel about the pH-sensing feeding tube versus the standard Dobhoff feeding tube. Please take the time to fill it out honestly and completely. Your help is greatly appreciated.

1. Approximately how many pH-feeding tubes have you placed?

2. Approximately how many Dobhoff feeding tubes have you placed?

3. What would you estimate your success rate to be in placing the pH-sensing feeding tubes in the duodenum?

4. What would you estimate your success rate to be in placing the pH-sensing feeding tubes in the stomach?

5. What would you estimate your success rate to be in placing the Dobhoff feeding tubes in the duodenum?

6. What would you estimate your success rate to be in placing the Dobhoff feeding tubes in the stomach?

7. How often do you send a patient to fluoroscopy?

8. What are your personal feelings on the pH-sensing feeding tubes?

Thanks, have a great day!
APPROVAL SECTION

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Program and Operations Analysis