Improving Procedures Of Children MRI Under Sedation - Benefits From Quality Control Circle

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Activity time: 2016.12-2017.06

Process Flow Chart

PDCA Loops

1. Problem selection
2. Activity plan
3. Current status
4. Target setting
5. Resolve
6. Formulation of countermeasures
7. Countermeasure implementation
8. Effect confirmation
9. Standardization
10. Review and Improvement
Chinese preterm infants ranks second
2 million premature babies per year
Increasing 200,000 per year
Over 10% newborns are premature baby in China
High risk of life long disability and death

50% of preterm infants have brain damage
Safe, high-resolution MRI--------
First Choice
Problem Selection - International Guidelines

American Academy of Pediatrics

01. Children <6 month
   Feed and rap

02. Children >6 month
    1-2 week preparation

03. Children with certain disease sedated by consult with anesthesiologist

04. Success rate after sedation --- between 80%-96%

Problem Selection - Definition

Definition of failure of examination

- MRI sequence can be numerous and independent
- Interruption of inspections, poor image quality ---- Fail Diagnosis. This is defined as failure of examination

Children’s MRI failure rate = \frac{\text{Incomplete sequences number}}{\text{Total sequence number}} \times 100\%
Problem Selection

Significance

For Hospital
- Avoid medical waste
- Highlight high precision
- Expanding leadership

For medical staff
- Improve machine efficiency
- Improve image quality
- Assisted clinical research

For the patient
- Shorten diagnosis and treatment time
- Reduced repeated sedation
- Improve diagnosis and treatment efficiency

Problem Selection-Example Case
Activity Plan

<table>
<thead>
<tr>
<th>WHAT</th>
<th>WHEN</th>
<th>WHO</th>
<th>WHERE</th>
<th>HOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>2016.12</td>
<td>2017.01</td>
<td>2017.02</td>
<td>2017.03</td>
</tr>
<tr>
<td>Step</td>
<td>Week</td>
<td>3w</td>
<td>4w</td>
<td>1w</td>
</tr>
<tr>
<td>Select Problem</td>
<td>Jia &amp; Guo</td>
<td>Brain storming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Plan</td>
<td>Jin &amp; Li</td>
<td>Gantt chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Status</td>
<td>Alicia &amp; Tan</td>
<td>Checklist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Setting</td>
<td>Chen &amp; Hou</td>
<td>Pareto Diagram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolve</td>
<td>Raw &amp; Fan</td>
<td>Brain storming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solution</td>
<td>Jiao</td>
<td>Brain storming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Countermeasure</td>
<td>Zhao &amp; Yan</td>
<td>PDCA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>Wang</td>
<td>Checklist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardization</td>
<td>Xu &amp; Guo</td>
<td>Pareto Diagram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check and Improve</td>
<td>Cong &amp; Hua</td>
<td>Standard formulation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Current Status

- Total of 101 patients
- Each patient had 5 sequences
- Total of 505 sequences.
- 59 incomplete cases
- 147 incomplete sequences:
  - 86 conventional sequence
  - 61 functional sequence

Result: Children’s MRI failure rate = 29.1%
According to 80/20 rule, the main problem is:

Failure to achieve the desired sedation depth

<table>
<thead>
<tr>
<th>Problems</th>
<th>Frequency</th>
<th>Ratio</th>
<th>Accumulated percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to achieve expected sedation effects</td>
<td>46</td>
<td>78.0%</td>
<td>78.0%</td>
</tr>
<tr>
<td>Attack of diseases influencing the examination</td>
<td>3</td>
<td>5.1%</td>
<td>83.1%</td>
</tr>
<tr>
<td>The imperfection of the sedation process</td>
<td>3</td>
<td>5.1%</td>
<td>88.1%</td>
</tr>
<tr>
<td>Equipment failure</td>
<td>2</td>
<td>3.4%</td>
<td>91.5%</td>
</tr>
<tr>
<td>Family members refusing the sedation</td>
<td>2</td>
<td>3.4%</td>
<td>94.9%</td>
</tr>
<tr>
<td>Long appointment time</td>
<td>1</td>
<td>1.7%</td>
<td>96.6%</td>
</tr>
<tr>
<td>The adverse effect induced by sedation drugs</td>
<td>1</td>
<td>1.7%</td>
<td>98.3%</td>
</tr>
<tr>
<td>Worries of potential radiation</td>
<td>1</td>
<td>1.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Totals</td>
<td>59</td>
<td>100.0%</td>
<td>-</td>
</tr>
</tbody>
</table>

Target Setting

Target value

\[
\text{Target value} = \text{current status value} - (\text{current status value} \times \text{key improve value} \times \text{Circle capability})
\]

\[
= 29.1\% - (29.1\% \times 78.0\% \times 70.0\%)
\]

\[
= 13.2\%
\]

Declined 54.6%
Why is the sedation efficacy not good

Analysis

Why is the sedation efficacy not good

Analysis-Causes Verification

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Time</th>
<th>Patient</th>
<th>Dosage</th>
<th>Sedation drug</th>
<th>People</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01/01/2018</td>
<td>3 PM</td>
<td>A01</td>
<td>0.5 mL</td>
<td>No</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>01/02/2018</td>
<td>4 PM</td>
<td>A02</td>
<td>0.6 mL</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>01/03/2018</td>
<td>5 PM</td>
<td>A03</td>
<td>0.4 mL</td>
<td>No</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>01/04/2018</td>
<td>6 PM</td>
<td>A04</td>
<td>0.5 mL</td>
<td>Yes</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>01/05/2018</td>
<td>7 PM</td>
<td>A05</td>
<td>0.6 mL</td>
<td>No</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Scene

Object

Reality
### Analysis- Causes Verification

<table>
<thead>
<tr>
<th>Checking items</th>
<th>Frequency</th>
<th>Ratio</th>
<th>Accumulated Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstandardized appointment process</td>
<td>9</td>
<td>32.1%</td>
<td>32.1%</td>
</tr>
<tr>
<td>Lack of sedation evaluation tools</td>
<td>8</td>
<td>28.6%</td>
<td>60.7%</td>
</tr>
<tr>
<td>Noisy environment</td>
<td>5</td>
<td>17.9%</td>
<td>78.6%</td>
</tr>
<tr>
<td>Lack of training</td>
<td>2</td>
<td>7.1%</td>
<td>85.7%</td>
</tr>
<tr>
<td>Parents unaware of the sedation requirements</td>
<td>1</td>
<td>4.5%</td>
<td>89.3%</td>
</tr>
<tr>
<td>Registration staff unaware of precautions</td>
<td>1</td>
<td>3.6%</td>
<td>92.9%</td>
</tr>
<tr>
<td>Lack of communication platform</td>
<td>1</td>
<td>3.6%</td>
<td>96.4%</td>
</tr>
<tr>
<td>Sedated too early</td>
<td>1</td>
<td>3.6%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### Countermeasures

1. **A standard appointment procedure for children’s MRI exam**
   - 1.1 Establishing an MRI registration appointment procedure for children
   - 1.2 Develop precautions list for children MRI exam

2. **A sedation evaluation standard for children’s MRI exam**
   - 2.1 Utilizing the University of Michigan Sedation Scales (UMSS)
   - 2.2 Sedation evaluation training and first aid training
   - 2.3 Evaluate after sedation and follow-up

3. **Noise influence reduction**
   - 3.1 Utilizing noise reduction tools and dedicated coil
   - 3.2 Adjust sequence order
   - 3.3 Repair motion artifacts
Countermeasures 1

A standard appointment procedure

Countermeasure content

Setup a appointment registration procedural
Registration staffs trained and tested regularly

Countermeasure effect

The implementation rate is 98%. Inspection failure rate decreased from 29.1% to 21.4%.

Countermeasures 2

A sedation evaluation standard

Countermeasure content

Sedation evaluation training for MR technicians
Matching the sedation time and the exam time
Re-evaluate the sedation depth after the examination, contact the physician in charge if over sedated

Countermeasure effect

Confirm that UMSS is an effective sedation assessment tool; Promote in the department and include into standardized documents.

Failure rate before and after the countermeasures

Failure rate declined

26.5%

23.8%
Countermeasures 3

Noise influence reduction

Countermeasure content
- Use noise reduction tools
- Adjust the sequence order
- Repair motion artifacts

Countermeasure implementation
- April 24 to May 12, 2017
- A total of 31 children were included, 155 sequences were scanned, and 21 failure sequences were obtained. The failure rate was 13.6%.

Countermeasure effect confirmation
- The implementation rate is 100%
- Inspection failure rate decreased from 16.3% to 13.6%

In practice, adjusted the sequence order individually.
Promote to peers.

Failure rate before and after the countermeasures

Failure rate decline 16.6%

Countermeasures 3

Sound proof earmuffs
Sleeping state
Dedicated coil

Use noise reduction tools and special coils
Countermeasures 3

Noise influence reduction

Adjust sequence order

3-pl Loc
Asset Cal
Ax T2Prop
Ac T2Flair Prop
3D-T1FSPGR
Young DTI
Young DKI

Move the loudest sequence T2 Flair to the last to scan

Countermeasures 3

Noise influence reduction

Motion correction software
Repair motion artifacts
Effect Confirmation

Inspection summary

<table>
<thead>
<tr>
<th>Problems</th>
<th>Frequency</th>
<th>Ratio</th>
<th>Accumulated percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to achieve desired sedation</td>
<td>21</td>
<td>47.7%</td>
<td>47.7%</td>
</tr>
<tr>
<td>Disease break out</td>
<td>5</td>
<td>11.4%</td>
<td>59.1%</td>
</tr>
<tr>
<td>Equipment breakdown</td>
<td>5</td>
<td>11.4%</td>
<td>70.4%</td>
</tr>
<tr>
<td>Adverse event</td>
<td>4</td>
<td>9.1%</td>
<td>79.5%</td>
</tr>
<tr>
<td>Long appointment time</td>
<td>4</td>
<td>9.1%</td>
<td>88.6%</td>
</tr>
<tr>
<td>Parents refuse to receive requisite sedation</td>
<td>3</td>
<td>6.6%</td>
<td>95.5%</td>
</tr>
<tr>
<td>Imperfect sedation procedure</td>
<td>1</td>
<td>2.3%</td>
<td>97.7%</td>
</tr>
<tr>
<td>Fear of radiation</td>
<td>1</td>
<td>2.3%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

91 cases × 5 sequences each = 455 sequences in total
44 incomplete cases in total
40 conventional sequences + 22 functional sequences = 62 unfinished sequences

Failure rate in children’s MRI = 13.6%

Effect Confirmation - Tangible Achievement

(1) Target compliance rate = \( \frac{(13.6\%-29.1\%)}{(13.2\%-29.1\%)} \times 100\% \)
Compliance rate = 97.5%
The basic failure rate reaches the target value after the intervention.

(2) Decline rate = \( \frac{13.6\%-28.5\%}{28.5\%} \times 100\%
Decline rate = 53.3%
This activity has made great progress and the progress rate has reached 53.3%.
Effect Confirmation - Tangible Achievement

Comparison of failure rates of conventional sequences before and after activity
The drop was 48.2%.

Comparison of failure rates of functional sequences before and after activity
The drop was 60.3%.

The average time needed for each child before and after the activity was 27.9%.

Comparison of average daily inspections before and after the activity.
An increase of 124.7%.

Effect Confirmation - Intangible Outcomes

Intangible achievement score sheet

<table>
<thead>
<tr>
<th>Evaluating item</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Totals</td>
<td>Average</td>
</tr>
<tr>
<td>Positivity</td>
<td>50</td>
<td>3.1</td>
</tr>
<tr>
<td>Responsibility</td>
<td>38</td>
<td>2.4</td>
</tr>
<tr>
<td>Cohesive force</td>
<td>46</td>
<td>2.9</td>
</tr>
<tr>
<td>Problem-solving ability</td>
<td>44</td>
<td>2.8</td>
</tr>
<tr>
<td>Communication and Cooperation</td>
<td>48</td>
<td>3</td>
</tr>
<tr>
<td>Technique of quality control</td>
<td>38</td>
<td>2.4</td>
</tr>
<tr>
<td>Harmony degree</td>
<td>42</td>
<td>2.6</td>
</tr>
<tr>
<td>Pleasure</td>
<td>40</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Radar chart of intangible achievement
Reduce the costs
100 yuan/person/day * 0.5 day = 50 yuan/person

Shorten hospitalization days
Avoid repeated inspections 0.2 times/day * Reduce hospitalization days 2/4 Total number of inspections 4 times/day = 0.1 day

Patient

Reduce the disturbance to children’s circadian rhythm by sedation or sleep preparation
Reducing the psychological stimuli of children due to environmental changes

Save parent’s time and reduce the burden of care 24 hr/person

Effect Confirmation- Additional Benefits

Medical staff
Avoid duplicate inspections Improve image quality Improve doctor-patient relationship
Improve work efficiency Reduce working hours 2 hr/person
Improve diagnostic accuracy and report quality
Improve the utilization rate of machines, increase the number of inspections, and increase income.

Daily income increase: (2.09-0.93) times/day * 600 yuan/time = 696 yuan/day.

Annual income increase: 696 yuan/day * 250 work days = ¥0.1705 million/yr.

Save electricity and equipment maintenance costs.

Save electricity costs 200 yuan/day, equipment maintenance costs 100 yuan/day, total 300 yuan/day; annual savings: 300 yuan/day * 250 work days = ¥75,000/yr.

Accelerate the progress of inspections and report issuance.

Improve the marginal benefits of human and equipment investment.

Accelerate scientific research output.

Enhance the cohesion.

Department of radiology

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Enhance the cohesion.

Accelerate scientific research output.

Department of radiology

Effect Confirmation - Additional Benefits

Society

Public Service Activities – Reported by Medias - Expanding Social Influence
Review and Improvement

Circle activity review summary

<table>
<thead>
<tr>
<th>Events</th>
<th>Advantage</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme selection</td>
<td>Significant clinical significance, and assisted scientific research.</td>
<td>Continue to carry out, use more data to support and establish a better inspection specification.</td>
</tr>
<tr>
<td>Plan activities</td>
<td>Reasonable time schedule and other divisions of labor.</td>
<td>Total quality circle activity, the annual summary and plan are slightly in error.</td>
</tr>
</tbody>
</table>

Remaining issues:
1. MRI in children is still dominated by sedative medication-assisted sleep
2. The pediatric MR examination industry standards and specifications are yet to be established

Outlook--Be Better

Explore pre-examination criteria
Improve compliance and safety
Promote optimization clinical path
Explore children’s MRI examination program in China
THANK YOU!

Jia Ying Circle