Workflow Modeling and Analysis of Computer Guided Prostate Brachytherapy under MR Imaging Control

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Abstract. We demonstrate that classical Business Process Reengineering (BPR) methods can be successfully applied to Computer Aided Surgery while increasing safety and efficiency of the overall procedure through an integrated Workflow Management System. Computer guided Prostate Brachytherapy, as a sophisticated treatment by an interdisciplinary team, is perfectly suited to apply our method. Detailed suggestions for improvement of the whole procedure could be derived by our modified BPR method.

1. Introduction

We examined the workflow of the complex, strongly data driven, clinical procedure of MR Image guided prostate brachytherapy. The patient population are men with low risk prostate cancer. Radioactive seeds are placed in the peripheral zone of the prostate gland while the patient lies under general anesthesia in an interventional MR scanner (GE Signa SP/i 0.5T). Near real time images display the current seed positions allowing a continuous update and improvement of the calculated dose plan [1].

2. Methods

We supplemented the standard Business Process Reengineering methods [2] with a safety oriented analysis of the dataflow [3]. A fundamental rethinking of the process as a whole was guided by the methods in table 1.

During 6 months we monitored in detail 22 brachytherapy procedures. Furthermore, we reviewed internal documentation of 330 identical procedures within the last 5 years and conducted interviews with healthcare personnel and involved physicians.

Our findings were visualized in process flowcharts as well as in high-level Petri nets of the dataflow. The key processes were identified and analyzed, and detailed recommendations for redesigning were developed.
### Table 1. Applied BPR Methods

<table>
<thead>
<tr>
<th>Classical BPR Methods</th>
<th>Safety enhancing BPR Methods</th>
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<tr>
<td>• Define the objective of each task and eliminate those that add no value</td>
<td>• Simplify wherever possible</td>
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<tr>
<td>• Identify one responsible for each task</td>
<td>• Try to reduce interfaces</td>
</tr>
<tr>
<td>• When possible perform tasks in parallel</td>
<td>• Strive for machine-to-machine interfaces instead of human-to-machine or machine-to-human interfaces</td>
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<tr>
<td>• Strive for high resource flexibility</td>
<td>• Include automated validation wherever possible</td>
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<td>• Allow a resource to practice its specialty</td>
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<td>• Eliminate costs associated with paper documentation</td>
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<td>• Reduce time to transfer work between tasks</td>
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<tr>
<td>• Automate wherever possible</td>
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<td>• Simplify wherever possible</td>
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### 3. Results

A Workflow Management System, that assigns tasks to appropriate personnel through an automatic paging system, while providing them with the necessary images, patient data, and the outcome of any preceding procedural steps, streamlines the operation significantly.

- Moving non patient related tasks such as segmentation and radiation dose planning out of the Operating Room OR suite increases flexibility of the specialists while improving the quality of treatment planning through better screening and integrated software. See Fig. 1 as an illustration of the workflow and Fig. 2 for the results of this proposal.

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**Figure 1.** Flow Chart of MR Image Guided Prostate Brachytherapy
Separating OR related tasks from OR independent tasks

Figure 2. Results of avoiding localization of tasks

- Better screen in reading room
- Specialists do not have to change to scrubs
- Shorter access routes
- Improved diagnostic quality
- Increased flexibility for specialists
- Decreased time span for specialists
- Shorter procedure time

Automated validation algorithms check the plausibility of data at various steps.
Direct visualization of the calculated seed positions on the template in front of the patient reduces errors due to possible misinterpretation and is the first step toward robot assisted seed placement.

4. Conclusion
We identified several critical points and bottlenecks that can be overcome by implementing our detailed suggestions. The risk of severe errors was reduced.
The presence of highly trained specialists was significantly lowered, while the stress level of the health care workers was decreased, as the Workflow Management System controls every task. This leads not only to a shorter door-to-door time but also to greater patient safety.

5. Discussion
Although numerous studies have examined the successful application of BPR methods in healthcare [4], we do not know of any comparable study in Computer Aided Surgery. We have shown that such methods, particularly when applied to complex computer supported surgical environments, have an enormous potential to identify procedural improvements and therefore have rewarding research potential.

References

