Any changes have taken place in the radiographic field as technology gradually changes from analog to computed radiography (CR) system and the digital radiography (DR) system. Developing countries such as Thailand, Vietnam, Cambodia and Myanmar have not been able to easily keep up with the rapid advances in radiographic technology.

If a hospital is growing from less than 300 out patients per day to over 3,000 patients daily and hospital bed occupancy rises from 150 beds to 250-350 beds, such as happened at Bangkok Hospital over the last ten years, then the X-ray department necessarily has to accelerate all processes in order to prevent "long wait times for outpatient procedures, due to backlogs."1

According to Professor Hermann, we compare CR and DR, "each type of system offers relative advantages, but DR may represent a better option for some facilities with a larger patient load due to the greater ease of use and elimination of cassette handling with DR. The ability to streamline workflow is a major advantage to DR systems, especially in facilities that regularly encounter a high patient volume. Even those imaging centers that do not currently have substantial scheduling constraints may see increased challenges in the future with the aging population and an anticipated dwindling of healthcare workers. Meanwhile, facilities could also be drawn to CR and DR systems as images are increasingly managed through PACS. While a CR image may take approximately 60 to 90 seconds to be processed and available for viewing, a DR image can be available” just 3 seconds after exposure.2

In this article we compare the different systems, and outline some possible design solutions for converting to DR (Table 1).

We look into 4 different scenarios of design for DR rooms which may be suitable for different hospitals, depending on the budget available for the x-ray department. Some of the newer DR technology today allows for DR plates to be used with bucky trays using wireless remote technology to transfer the image data.
Table 1: Comparison of operations and workflow for Screen-film, CR and DR system.

Screen-film

Computed Radiography (CR)

Digital Radiography (DR)
Scenario 1: Ideal DR System for 2 rooms with 2 wires and 2 wireless.

Equipments

1. 2 X-Ray machines.
2. Bucky stand 17x17 inches or 14x17 inches for 2 pieces wired system.
3. Flat detector 14x17 inches 2 pieces for wireless.
4. Control personal computer 2 sets.

Advantage:

- Complete for general radiographic service including large size patients.

Disadvantage:

- Highest cost of investment.

<table>
<thead>
<tr>
<th>Detectors</th>
<th>Patient Volume per Day</th>
<th>Patient Volume per Year</th>
<th>DR Cost (Approximate / Baht)</th>
<th>ROI* (Calculate over 5 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Detectors (2 X-Ray Rooms)</td>
<td>300</td>
<td>109,500</td>
<td>16,000,000.-</td>
<td>29.22 Baht / Image</td>
</tr>
</tbody>
</table>

Remark: Case volume assumption
*ROI = Return on investment
Scenario 2: DR system for 2 rooms with 2 wires and 1 wireless.

Equipments

1. 2 X-Ray machines.
2. Bucky stand 17x17 inches or 14x17 inches for 2 pieces wired system.
3. Flat detector 14x17 inches 1 piece for wireless.
4. Control personal computer 2 sets.

Advantage:
- Good for check ups of general patients and larger patients.
- Service flow is convenient.
- Cost of investment 25% less than Scenario 1.

Disadvantage:
- Because there is only one wireless device, service and patient flow might sometimes be slower, due to technicians only being able to do multiple positioning with a patient in one room at a time.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Patient Volume per Day</th>
<th>Patient Volume per Year</th>
<th>DR Cost (Approximate / Baht)</th>
<th>ROI* (Calculate over 5 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Detectors</td>
<td>300</td>
<td>109,500</td>
<td>12,000,000.-</td>
<td>21.92 Baht / Image</td>
</tr>
<tr>
<td>(2 X-Ray Rooms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remark: Case volume assumption
*ROI = Return on investment
**Scenario 3:** DR system for 2 rooms with 1 wire and 2 wirelesses.

**Equipments**

1. 2 X-Ray machines.
2. Bucky stand 17 x 17 inches for 1 device wired system.
3. Flat detector 14 x 17 inches 2 wireless devices serving 2 rooms.
4. Control personal computer 2 sets.

**Advantage:**
- Good for check ups, can cater for both general and larger patients.
- Service flow more flexible and convenient than Scenario 2.
- Cost of investment: 25% cheaper than Scenario 1.

**Disadvantage:**
- None

<table>
<thead>
<tr>
<th>Patient Volume per Day</th>
<th>Patient Volume per Year</th>
<th>DR Cost (Approximate / Baht)</th>
<th>ROI* (Calculate over 5 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Detectors (2 X-Ray Rooms)</td>
<td>300</td>
<td>109,500</td>
<td>12,000,000.-</td>
</tr>
</tbody>
</table>

**Remark:** Case volume assumption  
*ROI = Return on investment*
Scenario 4: DR System for 2 rooms with 2 wirelesses.

Equipments

1. 2 X-Ray machines.
2. Flat detector 14 x 17 inches 2 wirelesses devices serving 2 rooms.
3. Control personal computer 2 sets.

Advantage:

- Lowest cost.
- Service flow still flexible and convenient for patients.
- Cost of investment 50% less than Scenario 1.

Disadvantage:

- Unable to cater for larger size patients for chest examination.

<table>
<thead>
<tr>
<th>Patient Volume per Day</th>
<th>Patient Volume per Year</th>
<th>DR Cost (Approximate / Baht)</th>
<th>*ROI (Calculate over 5 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Detectors (2 X-Ray Rooms)</td>
<td>300</td>
<td>109,500</td>
<td>8,000,000.-</td>
</tr>
</tbody>
</table>

Remark: Case volume assumption

*ROI = Return on investment
Summary of differences

Scenario 1: Ideal Prototype.
Scenario 2: We can reduce 1 wireless DR plate.
Scenario 3: We can reduce by 1 wired DR plate, but service and patient flow remains flexible and convenient.
Scenario 4: We can exclude wired devices, thus reducing the DR plate from 4 pieces to 2; patient flow is still convenient. However, this scenario cannot cater for images of larger patients, because the flat detector plate for wireless devices is not fixed to the bucky tray.

Analysis

Scenario 1 is the most expensive investment. Scenario 2 or 3 will cost approximately 25% less than Scenario 1. Scenario 4 will cost about 50% less than Scenario 1. The choice of set up will of course depend on available budget.

Discussion

The ideal DR system should be:
1. As cost effective as possible.
2. Effective in terms of speed of use per patient.
3. Easy for technicians to operate.
4. Able to ensure patient comfort.

Hermann reminds us that “initial cost investment is the primary disadvantage of DR as compared to CR. CR can be easily integrated into an existing room structure whereas DR requires new radiographic equipment. Although an entire system overhaul to DR may offer greater streamlining of workflow, the costs of this upgrade could still be prohibitive to some facilities. In response to the high costs of upgrading the entire x-ray room or suite to DR, some vendors are offering DR tools that can be integrated into an existing CR platform. Now DR detectors have been developed that fit into a conventional cassette and bucky tray. A wireless transmission of images to the PACS allows facilities to take advantage of DR technology without upgrading the entire room.”

Conclusion

A DR combination of wire and wireless system is the ideal for general diagnostic purposes, and the investment needed of course depends on patient numbers and their requirements. As Selbert explains:

“Today, there are many types of digital radiography devices, including CR and several types of directdisplay digital radiography (DR). The challenge for users is to determine what best fits their imaging requirements. While upfront costs are important, you must also consider patient throughput, system maintenance costs, positioning capabilities, and other factors that contribute to overall operational expenses. This means there is no single “best” system for everyone.”

It also needs to be noted that not only is it expensive to convert to DR, but there is a time lag before benefits can be reaped. Radiology staff will need to be re-trained and there is a steep learning curve, not only with regard to operating the new technology, but because of work flow changes.

We would like to express our appreciation to Thai GL Co. Ltd for helping to provide us with data which we used in this paper. We hope that our summary provides a useful guide for other hospitals about converting to DR.

References