As the ED has evolved, the role of advanced diagnostics has exploded in the evaluation and management of our patients. Beginning with simple roentgenograms and basic laboratory analysis, our diagnostic capabilities have expanded to include advanced non-invasive imaging that has largely replaced exploratory surgery and the “wait-and-see” approach commonly used in the absence of diagnostics.

The concept of housing imaging within the ED had gained popularity, though at differing rates. The most readily available data from the United States and other advanced systems has shown a steady increase in imaging utilization. For example, data from the United States has demonstrated a five-fold increase in CT studies ordered in paediatric cases from 1995 – 2008 (Larson). Flattening and even declining utilization trends are also beginning to exhibit themselves for adult patients in advanced systems where CT scans have been readily available for many years (Levin, Menoch).

Part of what has driven increased use of imaging can be attributed to increased availability and practice in high-liability environments. While there is limited peer-reviewed data to suggest a correlation between availability of imaging in-department and utilization rates, links between liability concerns and utilization have been demonstrated (Smith-Bindman).

### In-ED imaging can improve efficiency, raise the quality of care and even help the bottom line.

Dr. Manuel Hernandez explains how to design it right from the ground up.

| TABLE 1 – Treatment Stations Required to Support Diagnostic Imaging by Imaging Demand |
|----------------------------------|-------|-------|-------|
| Number of Annual Imaging Cases   | ED #1 | ED #2 | ED #3 |
| Imaging Turnaround Time          | 48 min.| 36 min.| 20 min. |
| Total Care Time                  | 12,000 hrs.| 9,000 hrs.| 5,000 hrs. |
| ED Treatment Stations Required   | 1.8 stations| 1.4 stations| 0.8 stations |

1. Assumes 75% exam room occupancy target
The Case for In-ED Imaging

Planning for In-ED imaging begins with developing the business case for why investment in such expensive technologies will enhance performance, be it clinical quality, operational efficiency, financial performance or any combination of the three. Table 1 demonstrates the impact of imaging turnaround times on overall ED performance.

Looking at the cost of construction of unnecessary capacity and annual staffing costs to support patient care, the case for developing design solutions to reduce imaging turnaround times is clear. Building on the information in Table 1, Table 2 further explores the business case for in-ED imaging services.

Based on the information presented in Table 2, an investment in an in-ED x-ray unit would achieve break even on the investment within 2-3 years of implementation, while a CT scanner would break even on the investment within 5-7 years, depending on the technology purchased.

Other studies have looked at the cost effectiveness of use of advanced imaging modalities as a part of the ED evaluation phase as a strategy for reducing the overall cost of care. For example, use of coronary CT angiography in the ED as a part of an in-ED cardiac rule-out pathway has been shown to reduce overall length of stay for low-risk chest pain patients while also significantly reducing the total cost of care for the patient encounter (Goehler). In situations such as this, the investment in an


**Table 4 – ED Minimum Imaging Volumes By Modality to Justify In-ED Imaging Investment**

<table>
<thead>
<tr>
<th>SPECIAL PATIENT POPULATION / DESIGNATION</th>
<th>X-RAY</th>
<th>US</th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paediatrics</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>I</td>
</tr>
<tr>
<td>Trauma</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Acute Stroke</td>
<td>X</td>
<td></td>
<td>X</td>
<td>I</td>
</tr>
<tr>
<td>Chest Pain Center</td>
<td>X</td>
<td></td>
<td></td>
<td>I3</td>
</tr>
</tbody>
</table>

1. Frequent use of CT in the paediatric population is a topic of much debate in EM. As of the time of this publication consensus on In-ED CT except for high-volume / high-acuity paediatric centers does not exist.

2. Early studies at advanced academic medical centers are indicating benefit of early MRI in acute stroke patients. As of the time of this publication consensus on the value of in-ED MRI does not exist.

3. Studies investigating use of coronary CT angiography as a part of a rapid “triple rule-out” in low risk patients is showing benefit. This requires advanced CT technology, typically 64-slice dual source scanning capability of better.

in-ED CT scanner could yield a quick return on the investment in the technology.

**Imaging Modalities to Consider**

Selecting the proper imaging technologies can have a direct impact on speed to diagnosis, initiation of definitive management and overall length of stay in the ED. The selection criteria for what imaging to include within the borders of the ED should, at a minimum, include the following:

1. Annual imaging volumes (by modality) performed in the ED
2. ED acuity and special patient populations
3. Distance of ED from main diagnostic imaging services (immediately adjacent, distant, remote)
4. Availability of diagnostic imaging staff 24/7 or on-call
5. Potential impact on total cost of care
6. Annual ED Imaging Volumes

The addition of diagnostic imaging technology in the ED is no small investment. Because of this investment requirement, it is important to consider whether or not the demand for imaging services justifies the investment. While there is no industry-wide benchmark for imaging volumes that justify investment in imaging, this author considers the information in Table 3 as a useful guideline.

**ED Acuity and Special Patient Populations**

As EDs develop more and more specialty services, the speed to diagnosis and definitive management becomes evermore important. Similarly, as patient acuity levels increase in the ED, it can be expected that more and more demand for imaging services will develop. With this understanding in mind and based on current and future standards of care, this author considers Table 4 to be a useful guideline for in-ED imaging planning.

**Distance of ED From Main Diagnostic Imaging Services**

Studies analyzing the root causes of delayed ED imaging have indicated that order processing and patient transport times, along with imaging location, can all impact imaging turnaround times. A study of three urban Canadian EDs demonstrated that turnaround times for plain x-ray studies were shortened in the ED with an imaging unit within ED, while turnaround times were over 50% longer when the x-ray unit was located remote to the ED (Worster).

**Availability of Diagnostic Imaging Staff 24/7 or On-Call**

Staffing the imaging areas of the ED is another important consideration for in-ED imaging services. Clearly, a CT scanner in the ED is of no benefit if there is no staff to run it. Once an imaging modality is located within the borders of the ED, it is expected the service will be available 24/7 through either an in-house or on-call staffing model.

**Potential Impact on Cost of Care**

Throughout this article, examples of how diagnostic imaging has impacted the overall cost of care have been presented. Bending the cost-curve of emergency care and the total cost of care are important considerations that can be meaningfully impacted by careful imaging planning in any ED design. For example, selecting advanced CT technologies with subsequent elimination of oral contrast preparation for abdominal CT scans has shown to reliably decrease length of stay by as much as two hours or more without compromising quality (Levenson, Hopkins, Hlibczuk, Anderson).

**Designing the ED for Optimal Imaging Services**

While previous ED designs typically centered on placing in-ED imaging services deep within the ED and clustered together, newer designs are experimenting with decentralization of imaging services, placing each modality closest to its area of greatest demand. This said, as illustrated in Figure 1, extremely large ED (annual census > 100,000 visits) may benefit from centrally locating in-ED imaging relative to all treatment stations by reducing travel distances for patients and staff.

Varying the location of the imaging modalities within the ED can have a significant impact on overall speed to imaging and length of stay for all but the largest EDs. One ED that moved its fixed x-ray unit from deep within the ED to be adjacent to triage noted a 25% reduction in length of stay for patients requiring x-ray studies (Horton). The logic of this design approach is that lower acuity, ambulatory patients tend to rely on the fixed x-ray unit, while higher-acuity
patients tend to receive a higher number of portable x-rays in many EDs. Figure 2 demonstrates an ED design depicting a decentralized imaging model with x-ray located proximate to triage and lower acuity areas while CT is located closer to the trauma bays.

Figure 1 shows an ED design with x-ray immediate adjacent to triage. This design solution creates a patient flow that, where clinically-acceptable, allows the triage team to identify and order the appropriate imaging study with the patient receiving the x-ray prior to being placed in a treatment station with a resulting decrease in travel distances for the patient and staff. Figure 4 illustrates an ED design with the in-ED CT scanner located immediately across the corridor from the major resuscitation stations, reducing travel distances for the most critically-ill patients receiving care in the ED.

Portable imaging technologies have also been shown to add value and should be planned for appropriately. A 2010 Canadian study assessed the impact of a portable CT scanner in rural community hospitals linked to larger referral centers via a tele-stroke program resulted in increased ability to deliver thrombolytics to patients presenting with an acute ischemic stroke (Shaubai).

When planning for portable imaging modalities, the primary concerns in ED design are proximity and size. First, storage space for the portable units should be in close proximity to the staff using the technology and the patients most frequently requiring the corresponding imaging study. Second, ED treatment stations should be designed large enough to accommodate entry of the portable imaging technology into the room with the ability to easily access the patient from at least three sides.

Other important ED design considerations with respect to imaging focus on ensuring imaging staff have adequate workspace in proximity to where imaging services will be performed. Similarly, equipment necessary to process images should be immediately adjacent to where imaging studies will be performed to reduce overall staff travel distances and delays in study turnaround times. Equally important, locations where ED physicians and staff can view images should be readily available throughout the ED. This is most easily accomplished by ensuring adequate viewing monitors or, more recently, through the use of high-resolution portable tables with wireless connection to the imaging viewer.

An important non-facility design consideration is how linking EDs across a community can help reduce overall utilization of imaging modalities, particularly for patients being seen in multiple EDs or having multiple visits for the same complaint. One community developed a health information exchange that allowed all EDs to access the results of imaging studies performed at other EDs in the community. Access to previously-completed imaging studies resulted in a 64% decrease in repeat imaging studies for patients complaining of back pain (Bailey). Similarly, designing ED imaging services to support image import capabilities for patients being transferred to another ED for ongoing management has been shown to reduce reimaging (Bamberg, Sodickson). This would have the obvious benefit of reducing unnecessary radiation exposure and lowering the total cost of care. Figure 5 illustrates the design of a common imaging view room that can support both in-house and uploaded images.

Summary

Through careful planning, business case development and design, EDs can be developed to support best-in-class design features while enhancing the standard of care, improving overall efficiency and productivity of the ED, lowering length of stay and reducing the cost of care for multiple patient groups. Facilities planning new, renovated or expanded EDs are wise to carefully consider how diagnostic imaging will evolve and, based on this, what imaging should be considered for inclusion within the physical borders of the ED.

REFERENCES


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