Maximizing Radiologist Productivity
Optimizing display ergonomics to streamline radiologist workflow and decrease occupational stress

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Abstract

The impetus to do more with less has never been greater for hospitals, which must stay focused on their top priorities – patient safety, quality of care and cost containment – even as the patient population and the need for more advanced, complex care continues to grow.

Radiologists are bearing the brunt in the form of an ever-increasing workload, leading to longer days and the growing potential for occupational injuries related to pain, fatigue and stress. Proper ergonomics, in reading room configuration as well as an attribute of the diagnostic imaging display, can go a long way toward improving both workflow and reading comfort for clinicians.

This paper looks at the factors influencing radiologist productivity and well-being, illustrating how improvements in technology and design can enable radiologists to work more efficiently and comfortably, while maintaining diagnostic accuracy throughout their workday.
New era in healthcare places growing demands on radiologists
1. New era in healthcare places growing demands on radiologists

The global healthcare sector is undergoing a rapid evolution to meet the needs of a changing world: a growing aging population with more complex, chronic health needs; government initiatives which are increasing access to care in both industrialized and emerging markets; and treatment advancements expected to drive sector expansion. The United States likely will be dominated by the Affordable Care Act (ACA) implementation and consolidation; many European health systems are expected to be hampered by monetary/recession issues; and workforce shortages and access issues remain problematic around the globe.¹

In short, we are facing a challenging situation of shrinking budgets, increasing cost pressure, and growing demands to increase both the efficiency and the quality of services.² The impetus to do more with less has never been greater for hospitals, which must stay focused on their top priorities: patient safety, quality of care, and cost containment. In the midst of this storm are radiologists, many of whom are bearing the brunt of a rapidly growing and increasingly complex workload due to increased patient and physician demand for studies, expansion of clinical applications for advanced imaging, and defensive medical practices. Add to this, mounting pressures to boost productivity in a climate of declining reimbursements for diagnostic services, and radiologists are embarking on a collision course with severe occupational stress.

1.1 Occupational Stress on the Rise, Threatening Productivity and Well-Being

The fatigue and physical stress of their jobs can impact the amount of studies radiologists are able to read, their diagnostic accuracy and their overall health. Complaints of repetitive motion disorders, neck strain, and eye fatigue are growing among providers.³ As a result, radiologists are retiring early, some going out on disability, due to physical stress issues.

Eye fatigue is one of the most prevalent problems for radiologists who are tasked with reading dozens of studies per day, requiring them to stare intently at their screens for long hours. Often, this is caused by straining to see an image on the display in rooms that have poor lighting. Proper ambient lighting can help alleviate this problem, enabling radiologists to work more comfortably while maintaining diagnostic accuracy throughout their workday.

With increasing case volumes and longer workstation hours, radiologists may develop painful repetitive strain injury (RSI) symptoms that limit productivity.⁴ A study by Lindbeck L, Höglund U. showed that the use of digital systems results in more sedentary work and a substantial increase in headaches and musculoskeletal symptoms.⁵

Another major cause of discomfort is neck strain resulting from the frequent head movement required to view images on multiple screens in the typical radiology workstation configuration. Clearly, any attempt to consolidate the diagnostic display footprint in a way that mirrors the radiologist’s natural field of vision would reduce this practice and alleviate head and neck strain.

Considering all of the inherent stressors that are negatively impacting a radiologist’s ability to work comfortably and efficiently, there is a dire need to improve the ergonomics of diagnostic imaging displays and the overall reading environment.
Improving the reading experience through enhanced display ergonomics
When it comes to addressing the ergonomic effect of medical display attributes, there are several factors that influence the ability of the radiologist to read accurately and comfortably: field of vision, illumination, image quality, and image processing.

2. Improving the reading experience through enhanced display ergonomics

2.1 Field of Vision

As stated previously, most radiologists utilize a multi-display configuration to view all of the relevant images in a complete patient exam. This set-up requires them to continuously shift their eyes and rotate their head to even notice all of the images, a precursor to analysis and comparisons, since the combined display footprint exceeds their natural field of vision, i.e., the maximum area which can be viewed when one’s eyes are fixed on a single point. Cones of the human eye, responsible for the perception of details and colors, are concentrated near the center of the eye, so images outside the useful field of vision are less discernible. A more in-depth discussion regarding Field of Vision can be found in the Barco white paper Maximizing Radiologist Field of Vision.

Multi-modality display systems offer a viable alternative to the typical workstation arrangement for many types of studies. A 6 Megapixel (MP) diagnostic display provides the equivalent of two 3 MP displays on a single, bezel-free screen. Researchers at Montefiore Medical Center concluded that a single 6 MP medical display produced productivity gains of around 19 percent as compared to two 3 MP models, and was also found to reduce eye strain during reading sessions. An ideal alternative would be a display designed to match the radiologist’s natural field of vision, minimizing the need for head/eye movement so that he can comfortably view all images in a more relaxed, fixed position.

![Figure 1: Viewing angle with Coronis Uniti](image-url)
2.2 Illumination

While it is well understood that proper display brightness is critical to maintaining the radiologist's visual acuity as well as ensuring image quality, ambient light is a lesser known but just as critical factor in sound ergonomics. Radiologists can experience eye fatigue from straining to see the image on the display in rooms with poor lighting. This occurs because the eye is constantly adapting between the image brightness and the darker background. Adaptation requires both eye muscles, to open and close the pupil, as well as chemical changes to change the sensitivity of the eye. After many repetitions of adaptation between bright and dark, the eyes are tired and require recovery time.

Correct ambient light, including room and task lighting, can reduce eye strain and fatigue so that radiologists can read more comfortably – and accurately – for longer periods. Eliot Siegel, MD, a diagnostic radiology and nuclear medicine professor and vice chairman of informatics at the University of Maryland, suggests that hospitals “consider providing radiologists with individual ambient lighting and task lighting.” The ideal illumination balance is to achieve a consistent level between the monitor and the background surface, as shown in Fig. 1. The percent of radiologists complaining of a high level of fatigue drops from 50 percent to zero when room light matches monitor brightness. High levels of ambient light decrease diagnostic accuracy by 11 percent.

![Figure 2: Proper balance of screen illumination to ambient light](image)

2.3 Image Quality

Precise image quality is paramount to making an accurate diagnosis. Display brightness, contrast, color/grayscale accuracy and luminance stability are all important factors in achieving the best image possible on screen. When all of these attributes are optimized, radiologists can clearly see the image in its purest, most detailed form, easily identifying all of the normal structures and any artifacts or lesions with a high degree of certainty.
2.4 Image Processing

The speed at which a radiologist can upload, size, position and move through a study for optimal viewing is critical in facilitating efficient, comfortable reading of diagnostic images. If image manipulations are slow, lagging or uneven, it diminishes the radiologist’s performance and diverts attention from the task at hand. Early experience with digital mammography showed that speed limitations in hardware performance made film reading more efficient than softcopy reading. Yet when productivity tools were added and optimized, performance of softcopy reading was restored to equal or exceeded film reading, and ultimately improved the clinical outcome. Skaane explains that in the case of digital mammography, early trials (referring to Oslo I) “used prototype display equipment or a suboptimal softcopy display environment.” The correction of these factors and adding “image processing algorithms that were not present on prototype systems,” ultimately led to the improved outcome in the Oslo II trial.

2.5 Understanding the Relationship between Ergonomics and Productivity

Improving the ergonomics of diagnostic displays can go a long way toward enhancing radiologist productivity. When display system parameters are optimized to present pristine images that are easy to view, radiologists can read faster while maintaining a high degree of diagnostic accuracy. They can also read for longer periods when they are not combatting eye and neck strain and fatigue, completing more studies in an efficient manner without undue occupational stress.
An enterprise approach to streamlining workflow
3. An enterprise approach to streamlining workflow

To empower radiologists with a true performance advantage, hospitals also need to address enterprise workflow. One of the key limiting factors to streamlining workflow in today’s hospitals and radiology practices is the decentralized nature of imaging resources. Typically, PACS and breast imaging workstations are deployed throughout the hospital in various locations (see Fig. 2), requiring radiologists to visit different displays to obtain all of the images necessary to make a thorough diagnosis.

This situation results in lost time and concentration as radiologists travel throughout the facility to gather the requisite patient exams for a complete study or need to move to a different area of the facility for the next priority read. Many facilities partially solve this problem by installing a variety of diagnostic workstations in the radiology department; however, even when displays are located in the same room, it can be disruptive to move from station to station to view images.
3.1 Multi-Display Configurations Attempt to Solve the Problem

Going one step further, radiologists have created multi-display configurations to include a combination of color 3 MP and grayscale 5 MP displays with an auxiliary display (as shown in Fig. 3). However, this extremely wide display footprint can result in neck strain, as mentioned previously, which causes stress and pain for the radiologist, especially during long reading sessions.

3.2 Multi-Modality Workstations Evolve

In other words, the goal in creating a more ergonomic and efficient workflow is to make any image available, anywhere at any time – preferably on a single display. This is the workflow efficiency concept behind multi-modality imaging, where all relevant images can be viewed on a single screen, in color and grayscale, configured to the radiologist’s preference. However, the technology has extended only to PACS images, and while providing a quantum leap in productivity over single modality displays, has not been extended to enable simultaneous viewing of complex 3D and mammography exams.

Clearly, the solution is to compile all relevant images on a single display, which would be more convenient and comfortable for the radiologist. As Siegel reiterates, there’s never been a more critical need for improving the ergonomics of the radiology reading room. Volume and complexity is at an all-time high.\textsuperscript{11}
Unifying the radiology desktop -
the Coronis Uniti display system
4. Unifying the radiology desktop - the Coronis Uniti display system

The Coronis Uniti display system is an elegant, universal diagnostic display that improves radiologist productivity through enhanced ergonomics and workflow improvements. The first display explicitly designed for viewing both PACS and breast images, it unifies the radiologist’s desktop, bringing together all patient images on a single screen to facilitate the best possible diagnosis. As recommended by Siegel, it reinforces the notion that radiologists should try to have as many functions in a single workstation as possible.12

4.1 Experience a Different Field of Vision

Coronis Uniti has been designed to optimize the Field of Vision. The display size and unique 3:2 aspect ratio are a perfect fit for the human visual system. Coronis Uniti enables radiologists to read entire studies and multiple exams with virtually no extraneous head/eye movement, reading more comfortably for many hours without getting fatigued. Their visual acuity stays sharper much longer, resulting in greater diagnostic accuracy for the entire reading period. A more in-depth discussion regarding Field of Vision can be found in the Barco white paper Maximizing Radiologist Field of Vision.

With its unique 33” form factor, 12 MP resolution featuring 12 percent more real estate, and 1,000 cd/m² calibrated brightness, the Coronis Uniti presents the largest, brightest images with the sharpest resolution of any medical display on the market.

Other key features that boost productivity, clinical accuracy and working comfort include:

4.2 Faster Image Loading

The Coronis Uniti display system features high-speed controllers to quickly load the images on screen for uninterrupted workflow. Moreover, because there are 12 percent more pixels on the screen, images can be displayed at 1:1, meaning less windowing and leveling is required to present the best image for analysis. Radiologists can view a life-size image with minimal panning and zooming and fewer time-consuming – and physically taxing – mouse clicks. The time advantage of displaying more images on the screen was examined by Bacher13; it was found that compared to a 5 MP display system, “In the digital mammography setting, the analysis with the 3-megapixel LCD also resulted in a significant longer evaluation time (p = 0.035).”

Often, there is a tradeoff between speed and another parameter such as blurriness. Following the data from Platisa14 on detection in breast tomosynthesis cine loops, it is possible to measure how a display system optimized for speed with features like RapidFrame™ would outperform a display designed for static images. In her research, performance with RapidFrame at 15-25 frames per second is equivalent to using a display without that feature at 5 frames per second.
4.3 High Image Quality

Because of the display’s excellent local contrast and consistent luminance, radiologists can easily view the smallest, most subtle details. The Optical Glass technology displays sharp images with less reflection, which also reduces eye strain. Coronis Uniti also features several workflow tools designed to further emphasize and illuminate specific image areas, including SpotView and I-Luminate, while Per Pixel Uniformity facilitates detection at the most minute level. Fig. 4 shows how, as luminance and thus perceived contrast increases, there is a corresponding increase in the probability of detection.

![Figure 4](image)

**Figure 4**: Detection probability increases with perceived contrast

4.4 Multi-modality

Color and grayscale images, single and multi-frame, 2D and 3D, static and moving, even PACS and mammography images can be presented side-by-side on the display for easy viewing on an extra-large, bezel free screen (Fig. 5). Coronis Uniti’s SteadyColor and Color PPU technologies present accurate and calibrated grayscale and color together on the same display network. With the virtual lightbox, radiologists can also place prior films directly on the display adjacent to digital images for comparison purposes.

Much more versatile than typical multi-modality displays, Coronis Uniti provides a significant advantage for smaller radiology departments and imaging centers that have fewer opportunities to specialize, allowing radiologists to read multiple types of studies on one display. Coronis Uniti can replace a multi-display set-up comprising two 3MP color displays and two 5MP grayscale displays to provide a streamlined approach with increased functionality and image-enhancing capabilities. This consolidated footprint also reduces stress on the radiologist by minimizing head/hand/eye movement.
4.5 Mammography & PACS

Coronis Uniti is the only display capable of presenting digital breast tomosynthesis images, standard 2D mammography and color PACS images all on one large screen. It is also future-ready for color on mammography images, color CAD, and color annotation to optimize the workflow. Radiologists can arrange breast images according to layout and size preferences, and make an easy adjustment between clear base and blue base display modes.

![Figure 6](image)

Figure 6: Both PACS and mammo images can be displayed side-by-side on the same screen

4.6 Adjustable Ambient Light

As mentioned, ambient light plays a significant role in both diagnostic accuracy and reading comfort. Luminance is strongly correlated with the conspicuity of mammographic targets. The display luminance and ambient light should be equalized to provide the best viewing experience and more constant adaptation. The optimal reading conditions can easily be achieved with the SoftGlow ambient lighting feature on the Coronis Uniti, which allows the user to control the amount of wall and task lighting.

4.7 Toward a more simplified reading environment

Coronis Uniti streamlines support needs for the reading environment, establishing a consistent platform that simplifies set-up, management and maintenance over time. Because it’s a unified PACS and mammography reading station, it fulfills the widest range of imaging needs with all exams, conveniently at the radiologist’s fingertips, enhancing workflow and increasing productivity throughout the day. From an IT administration perspective, it solves the problem of managing multiple displays, devices, drivers, and software and it displaces displays that may not be fully utilized. The result: a more efficient technology footprint for the radiology department.

4.8 PACS and IT specialists benefit from streamlined resources

PACS Administrators and IT Specialists at hospitals and imaging centers are charged with ensuring optimum performance and utilization of display assets in order to meet both patient care and facility revenue targets. Because Coronis Uniti simplifies workstation management on a universal reading platform, facilities can retire redundant or underused displays as well as eliminate cumbersome and disparate devices and accessories. This configuration also streamlines workflow by allowing radiologists to read any image, anytime and anywhere, enabling staff to work more efficiently, and thus increase their productivity. This time, money and personnel savings maximizes profitability for the diagnostic imaging department or facility by reducing overhead on radiology services.
5. Conclusion

Hospitals and radiology imaging practices must balance their need for increased revenues with a focus on preserving radiologists’ health and well-being. The use of proper ergonomics in the reading room can help them achieve both, enabling them to drive increased productivity while reducing the potential for occupational stress. Reading room design can have a major impact on radiologists’ health, productivity and accuracy in reading.

The Coronis Uniti provides a solution to the growing challenges radiologists face in fulfilling the diagnostic imaging demands of a busy practice. By virtue of being able to satisfy mammography and PACS requirements in a single display station, equipment and radiologist utilization are improved. The Coronis Uniti’s unique ergonomic attributes, including distinct form factor and multi-modality imaging capabilities, help radiologists maximize their productivity while preserving their well-being.
6. References

4. Atalie C. Thompson, MD, MPH. Journal of the American College of Radiology, Stanford University’s School of Medicine and the University of California, Berkeley, and colleagues.