

Transducers — A Human-Machine Interface

Innovations in Ergonomic Design

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Growing concern over the high rate of work-related musculoskeletal disorders among sonographers has led imaging professionals to seek technology that makes an ergonomic difference, not just a clinical difference. Surveys done among American and Canadian sonographers, as well as in Australia, have shown that over 80% of sonographers are scanning in pain; 20% of these sonographers have been forced to give up their profession as a result of their injuries.² Most overuse injuries associated with physical labor are caused by repetitive eccentric muscle contractions.¹ By contrast, many of the overuse problems reported by sonographers, who often work in constrained postures are associated with sustained isometric contractions. Continued exposure can cause inflammation, swelling, and deterioration of tendons and ligaments, resulting in further stresses on muscles and joints. The human-machine interface between a sonographer and the transducer often results in sustained awkward postures of the hand and wrist. Innovations in transducer design are advancing improvements in efficiency and image quality through ergonomic design.

Of the most commonly identified injuries sustained by sonographers, 42% involve the hand or wrist, such as carpal tunnel syndrome, tendonitis, deQuervain's syndrome, and trigger finger. Fifty-nine percent of sonographers report work-related pain of the wrist, 55% report pain of the hand/fingers, and 31% report forearm pain.² Sonography risk factors for hand and wrist issues include force (due to applied transducer pressure and external torque related to transducer cables), awkward postures of the wrist and hand, and sustained grip forces. Poorly designed transducers create risk factors for WRMSD (work-related musculoskeletal disorders) as a result of awkward positions, mechanical compression, and forceful exertions. Furthermore, poor designs in hand tools can increase the risk for injury by affecting tendon function, compressing nerves, causing muscular fatigue/tissue stress, and affecting blood flow to muscles/tendons. Prevention includes avoiding twisting of hand/wrist by encouraging neutral postures, minimizing forceful gripping, and reducing forces working against the hand. Grasping power is decreased by approximately 50% if the hand is bent downward or twisted to either side,

which requires more muscular effort to hold the transducer. The carpal tunnel space is at its largest when the wrist is in a neutral position, giving the nine tendons and the median nerve that pass through the space the maximum amount of room. Dorsiflexion or extreme pronation or supination of the wrist increases pressure on the carpal tunnel, requiring more muscle activation of the forearm.

Engineering considerations in transducer design can reduce or eliminate the presence of risk factors. Many traditional transducer designs inherently create torque on the wrist at the location of the cable insertion, forcing the muscles of the hand and forearm to fire constantly to counteract the drag. Torque on the wrist, as well as the force required to grip the transducer can be reduced by designing transducers with lightweight, flexible cables and a balanced body, so the weight of the scanhead's center of gravity aligns with the center of the hand. Heavy transducers require excess grip force to hold them, causing static muscle loading and a more rapid onset of muscular fatigue. New transducers, such as the 17L5 by Siemens, weigh less than seven ounces and provide cable

flexibility through cable technology improvements that reduce torque on the hand by increasing flexibility where the cable exits the transducer. These technological improvements, along with housing design innovations contoured to fit the hand, have changed the sonographer-transducer interface as compared to conventional transducers. The palmar grip design approach seen in companies such as Siemens, incorporates form factors that assist the sonographer in reducing the risks associated with the traditional pinch grip design. Improved grip features through the use of textured overcoats on the transducer housing also reduce required grip force. This is particularly important because most sonographers now wear gloves while scanning which, when combined with gel, creates a slippery surface.

Traditionally, scanhead shapes have necessitated a pinch grip due to the nature of their design. However, grip force is four times stronger in palmar (whole hand) grip than a pinch (fingers) grip.³ Applying this theory to scanhead design helps minimize the risks associated with the traditional pinch grip used to hold the transducer. Emerging technologies have resulted in new transducers with unique ergonomic shapes designed to be operated with the hand held in a more neutral position and utilizing a palmar grip. Optimizing transducer size and shape for an efficient palmar grip reduces muscular effort and facilitates more efficient gripping. This type of innovation in equipment design supports positive changes in how sonographers hold transducers. Multi-frequency capabilities can reduce the need to frequently change transducers by providing a range of scanhead frequencies, and technology improvements can reduce struggle time by clarifying the imaging of technically difficult patients.

Conclusion

The effective implementation of process improvement often involves re-thinking some primary truths and being willing to consider alternatives. Advanced transducer technologies are fostering changes that result in efficiency improvements by improving image quality and ergonomic design. Ultrasound systems have undergone significant re-design changes in recent years to incorporate ergonomic features into their development. Modifications in transducer design are the logical next step in the process. Minimizing the strain involved in gripping the transducer reduces overall muscular effort, improving endurance, and worker safety.

References

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The unique design of the 17L5 transducer promotes a palmar grip reducing pinch grip and operator fatigue.



The 17L5 transducer incorporates a unique ergonomic design with a textured elastomeric case to improve transducer control and reduce grip force.

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