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Original contribution

Ergonomic task analysis of ultrasound-guided femoral nerve block: a pilot study☆

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Abstract
Study Objective: To apply ergonomic task analysis to the performance of ultrasound-guided (US-guided) femoral nerve block (FNB) in an acute hospital setting.
Design: Pilot prospective observational study.
Setting: Orthopedic operating room of a regional trauma hospital.
Subjects: 15 anesthesiologists of various levels of experience in US-guided FNB (estimated minimum experience < 10 procedures; maximum about 50 procedures, and from basic trainees to consultants); and 15 patients (5 men and 10 women), aged 77 ± 15 (mean ± SD yrs) years.
Measurements/Observations: A data capture "tool", which was modified from one previously developed for ergonomic study of spinal anesthesia, was studied. Patient, operator, and heterogeneous environmental factors related to ergonomic performance of US-guided FNB were identified. The observation period started immediately before commencement of positioning the patient and ended on completion of perineural injection. Data were acquired using direct observations, photography, and application of a questionnaire.
Main Results: The quality of ergonomic performance was generally suboptimal and varied greatly among operators. Eight (experience < 10 procedures) of 15 operators excessively rotated their head, neck, and/or back to visualize the image on the ultrasound machine. Eight operators (experience < 10 procedures) performed the procedure with excessive thoracolumbar flexion.
Conclusion: Performance of US-guided FNB presents ergonomic challenges and was suboptimal during most of the procedures observed. Formal training in US-guided peripheral nerve blockade should include reference to ergonomic factors.

1. Introduction

Ergonomics is the science of physical interaction between humans and their working environment, while "human

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factors engineering" is the study of underlying cognitive elements responsible for such interaction. The application of ergonomic strategies requires the study of body mechanics, the nature of the work performed, and the individual performance of a worker. When successfully applied, such strategies may optimize system performance while maximizing human well-being and operational effectiveness. Ergonomics also embraces a range of issues relevant to equipment or systems design and training: motion and strength capabilities (biomechanics), sensory-motor capabilities—vision, hearing, haptics (force and touch), and dexterity [1].

Due to advances in medical knowledge and biomedical technology and the expectations of the society, medical professionals currently work in complex and demanding environments. One example of this is the work of an anesthetist/anesthesiologist in a modern operating room (OR). Although ultrasound-guided (US-guided) peripheral nerve blockade is now widely practiced and its use is likely to increase further, most ORs have not been modified according to the requirements of US-guided peripheral nerve blockade. As the operators performing this technique respond to visual, haptic, and auditory input from multiple sources, the procedure presents an ergonomic and clinical challenge, especially in an environment that has not been designed or prepared for these procedures. There is growing recognition of the relevance of ergonomics to surgery and anesthesia practice [2,3]. To date, ergonomics is not taught in most anesthesiology training programs although the potential benefits of such teaching have been recognized [4-6]. Evidence exists that even simple and short surgical procedures carry occupational hazards if ergonomic principles are overlooked [7]. The first step in identifying a need to change practice or training was to perform a preliminary observational pilot study of anesthesiologists' ergonomic performance in a "real world" clinical setting. The principal objective of this pilot study was to apply ergonomic task analysis to performance of US-guided femoral nerve block (FNB) in a busy acute hospital setting [8].

2. Materials and methods

With approval of the Clinical Research Ethics Committee of the Cork Teaching Hospitals, Cork, Ireland, and having obtained written, informed consent from each participating subject (patient and anesthesiologist), a pilot prospective observational study of anesthesiologist's ergonomic behavior while performing US-guided FNB was undertaken in a busy orthopedic OR using ergonomic task analysis [9]. In this setting, US-guided FNB is frequently performed on patients undergoing lower limb trauma surgery of hip, knee, or femur as an adjunct to general anesthesia, or to facilitate positioning for spinal anesthesia.

A data capture "tool", which was developed to study the ergonomics of spinal anesthesia, was modified based on a series of multidisciplinary (anesthesiologists, occupational health physician, and ergonomist) discussions [10]. Adjustments included parameters and ratios to indicate quality of ergonomic performance of US-guided FNB, eg, the operator's degree of rotational movement to visualize the image on the US screen.

The preliminary version of this tool was piloted on three procedures; the resulting minor modifications led to the final version. For instance, in the preliminary version of the tool, the height of the US screen was measured from the ground to the top edge of the screen; in the final version, this height extended to the vertical midpoint of the US screen. Development of the tool was guided by applicable basic ergonomic principles [1].

The areas of interest were patient, operator, and environmental factors of ergonomic relevance. For instance, patient factors included height of skin puncture point and distance of skin puncture point from the (proximal) edge of the OR table. Operator factors included the position of the operator relative to the US machine, the operator's (back) posture, and his/her rotational head, neck, or back movements during the procedure. Factors other than patient and operator were included in a heterogeneous group of environmental factors, eg, light intensity and position of a dedicated assistant relative to the operator during the procedure. The final version of the tool was then applied to 15 procedures to acquire qualitative and quantitative data. The data capture tool is shown in Appendix A.

Fifteen anesthesiologists (operators) at different levels of training and variable previous experience in US-guided FNB and 15 patients undergoing lower limb trauma surgery of hip, femur, or knee, were recruited for this study. Recruitment took place between March and June, 2009. Recruitment was intermittent, depending on both patient and anesthesiologist consents and the availability of a single dedicated investigator with responsibility for real-time data collection. Obesity (BMI > 30 kg/m^2), anticoagulation (INR > 1.2), previous surgery (eg, inguinal herniorraphy), or any lesion/deformity in the area (eg, cyst, infection, or lipoma of the inguinal region) were patient exclusion criteria. Anesthesiologists were directly observed performing US-guided FNB in the orthopedic trauma OR. Patients also were directly observed for the presence of distress before, or on positioning for, the procedure. The blocks were performed while patients were on the bed or trolley used to transport them. There were no standardization of set-up other than the US machine (M-Turbo 6 – 13 MHZ; Sonosite, Inc., Bothell, WA, USA) and block needles (Stimuplex A 0.8 × 50 mm; B. Braun, Melsungen, Germany) used, and the nature of available assistance was similar in all the procedures. The observation period started immediately before commencement of patient positioning and ended on completion of perineural injection of the local anesthetic.

Data were acquired using direct observation, photographs taken during the procedure, and application of a questionnaire that was distributed to operators at the end of each