Educational and clinical aspects of peripheral nerve blockade
Wegener, Jessica

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Chapter 9

Summary

General conclusion
Summary

Chapter 1
Peripheral nerve blocks became an essential part of regional anesthesia and have a growing interest. Previous and present developments for performance of peripheral nerve block techniques are described. High frequency ultrasonography for guidance of peripheral nerve blocks was the latest important invention. Ultrasonography enables to visualize target nerves, adjacent vital structures, needle advancement and the spread of local anesthetics during its administration. However, this technique requires totally new skills and proficiency of the anesthesiologist.

Ultrasound guidance gave rise to more frequent and wider clinical application of peripheral nerve blocks. Large groups of patients may benefit from peripheral nerve blocks for postoperative pain control after surgery of their limbs. Patients undergoing total knee arthroplasty experience improved postoperative pain control and mobilization with peripheral nerve blocks.

Chapter 2
Education and learning of ultrasound-guided regional anesthesia is reviewed according to the recommendations of the European and American Society for Regional Anesthesia in 4 steps. Models, phantoms, cadavers and simulators are helpful tools for educating ultrasound guided regional anesthesia. Generally, teaching programs using objective measures to control the learning progress improve the results. Still, there is an urgent need for further research to compare different educational techniques, to develop true high-fidelity simulators and to test their efficiency. Education programs should be tailored to the individual needs of a trainee. More importantly, the effects of improved training programs on quality of care should be investigated.

Chapter 3
Identifying sono-anatomy is an important part of the learning process when starting ultrasound guided regional anesthesia.

An embedded electronic tutorial as an element of an ultrasound machine may help to identify sono-anatomy for novices. Therefore, we investigated in a randomized controlled study whether an embedded electronic tutorial could improve accuracy or speed of performance in identifying anatomical structures. Novices in ultrasound guided regional anesthesia participated in a workshop on brachial plexus sono-anatomy. Following a lecture and training in handling of
ultrasound machines and hand-eye coordination, participants were randomized in either a group using a standard ultrasound machine, or a group using the same type of machine with an onboard electronic tutorial. A significant increase in correct identifications was achieved with help of the tutorial at the expense of significantly longer time required for this process. Increased time required may partly be related to unfamiliarity with the tutorial.

Chapter 4
Several years ago a percutaneous electrical nerve stimulation pen was introduced for non-invasively localizing superficial nerves. This technique would facilitate the performance of a nerve block. The function of the pen was based on the theoretical linear relationship between current thresholds and electrode-to-nerve distance. However, the current to distance relationship is rarely linear because of varying electrical impedance in biological tissues. The reliability of a percutaneous electrical nerve stimulation pen was never studied. Therefore we measured stimulation thresholds and impedances of the brachial plexus with the pen systematically at 49 locations of the skin at the interscalene groove of volunteers. We compared the stimulation thresholds and impedances of the pen to distances at the same locations from skin to plexus, measured with ultrasound. Only in 10% of the locations a relationship was found between stimulation thresholds and distances. Thus, use of the percutaneous electrical nerve stimulation pen cannot be recommended.

Chapter 5
When performing an ultrasound guided axillary brachial plexus block visibility of the radial nerve, often hidden behind the axillary artery, can be challenging in the traditional arm position of shoulder and elbow bent at 90°. Therefore we studied the influence of arm positioning on visualization of the brachial plexus at the axilla in volunteers. Visibility of the nerves and distances to the artery were determined in eight different arm and scan positions and analyzed on captured video clips by two blinded observers. Visibility of the radial nerve did not improve in different arm positions. However, the distance between the radial nerve and the artery was significantly greater and the visibility of the median and ulnar nerves significantly improved in a position of shoulder 180° and elbow straight. Arm position of shoulder 180° and elbow straight provided the best overall visibility and accessibility of nerves. Different causes of poor visibility of the radial nerve are discussed. Whether the same results will be find in older or obese patients is still unknown, but adaption
of the traditional arm position may facilitate the performance of an ultrasound guided axillary brachial plexus block.

**Chapter 6**

One of the advantages of ultrasound-guided peripheral nerve blocks regarding safety is the visualization of the spread of local anesthetics, allowing a dose reduction. Recently, research has been focused on reducing local anesthetics to a minimum effective volume for establishing an adequate peripheral nerve block when using ultrasound. However, effects of reduced volumes on block duration are unknown. Therefore, we assessed the duration of action of an ultrasound-guided single shot axillary brachial plexus block after a 60% reduction of mepivacaine 1.5% (15 vs 40 ml) in a prospective randomized, observer-blinded trial. The overall duration of sensory and motor block was significantly reduced by 17% and 19% respectively, whereas time to first request of postoperative analgesia was shortened by 30%. Reduction in block duration for individual nerves was larger, varying from 20% to 40% for sensory block and from 18% to 37% for motor block.

The advantages of dose reductions should be balanced against the shortened block duration. Still, effects of dose reduction in long acting local anesthetics has to be determined.

**Chapter 7**

Patients undergoing total knee arthroplasty can suffer from severe postoperative pain, which is known to impair early intensive physical therapy and rehabilitation. A continuous femoral nerve block during the first postoperative days improves postoperative pain control and rehabilitation. However, pain relief might be insufficient in the posterior region of the knee that is innervated by the sciatic nerve. Therefore we investigated whether the addition of a sciatic nerve block (single-injection or continuously) to a continuous femoral nerve block shortens time to discharge readiness and improves early postoperative knee function in a randomized controlled trial. Secondary, we assessed postoperative pain scores at rest and during mobilization and determined postoperative opioid consumption. This trial revealed that a single-injection or continuous sciatic nerve block in addition to a femoral nerve block did not influence time to discharge readiness or rehabilitation of knee function. Though, a single injection sciatic nerve block reduced severe pain on the day of the operation, while a continuous sciatic nerve block reduced moderate pain during mobilization on the first two postoperative days. Consumption of supplemental
Chapter 8
Poorly controlled severe postoperative pain has been identified as a key factor in the development of persistent pain in the long term after surgery. Therefore, we continued the previous trial (Chapter 7) with a follow-up whether an additional sciatic nerve block to a continuous femoral nerve block in patients undergoing total knee arthroplasty could improve long-term knee function and reduce pain after 3 and 12 months. Outcome was measured with two validated self reporting written questionnaires: The Western Ontario and McMaster Universities osteoarthritis (WOMAC) index questionnaire and the Oxford 12-item knee questionnaire (OKS). WOMAC index evaluates quality of life in the dimensions of pain (5 items), stiffness (2 items), and function (17 items). The OKS contains 12-items, assessing pain and physical disability). Pain was measured with the visual analogue scale (VAS) at rest and during mobilization. The collected WOMAC, OKS and VAS at 3 and 12 months were compared with preoperative baseline values. A post hoc median split analysis, based on the preoperative functional score (median baseline WOMAC index) was applied to test the hypothesis that only patients with severe disabilities and severe pain preoperatively (baseline WOMAC index < median baseline WOMAC index) might benefit from an improved postoperative pain management. Knee function improved greatly in all patients after TKA without any mid- and long- term effect of the addition of a sciatic nerve block (single injection or continuous) for patients undergoing total knee arthroplasty. Post-hoc subgroup analysis revealed that patients with poor preoperative knee function experienced less knee stiffness and pain during mobilization at the mid- and long term after addition of a sciatic nerve block for TKA. However, since groups and specially subgroups of poor preoperative functioning were small, it is entirely unclear whether this is a co-incidence by chance or a beneficial effect of the sciatic nerve block. Future research to long-term effects of an additional sciatic nerve block in preoperatively poor functioning patients undergoing total knee arthroplasty is recommended.
General Conclusion

Technical developments like ultrasound make performance of peripheral nerve blocks by anesthesiologists more effective. Guidance of ultrasound for peripheral nerve blocks need to be trained in a stepwise manner. Knowledge of site-specific anatomy is indispensible for the identification of sono-anatomy, but can be technically supported. From the perspective of patient comfort and safety, training methods of ‘learning by doing’ should be omitted. Future inventive simulators may enhance training of ultrasound-guided nerve blocks and will accelerate the learning curve. Use of ultrasound dramatically changes performance of peripheral nerve blocks concerning required amount of local anesthetics and corresponding duration of action, finding of most optimal patient posture and probe position for the optimal visibility and accessibility of the target nerves. All these technical and clinical adjustments will definitively benefit patients with an indication for use of single or continuous peripheral nerve blocks after undergoing limb surgery and risk of suffering in severe postoperative pain while early mobilization is imposed.