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SHORT COMMUNCIATION

Ultrasound guided spinal catheter insertion in piglet: preliminary results

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Abstract

Objective To describe the ultrasound (US) evaluation of the cervical, thoracic and lumbar spinal tracts in piglets and to evaluate the feasibility of the ultrasound guided spinal catheter placement in newborn and paediatric piglets.

Study design Prospective experimental study.

Animals A total of two piglet cadavers (age, 7 and 14 days) and eight commercial crossbreed piglets divided into four groups according to age: 7 (P7), 14 (P14), 21 (P21) and 28 (P28) days.

Methods In the first part of the study an ultrasound examination of the spinal tract was performed in piglet cadavers applying the transverse and the longitudinal approaches in sternal and lateral recumbencies. In the second phase, the piglets were anaesthetized with sevoflurane. A US examination with a 10 MHz linear probe was performed and a spinal catheter was introduced between the spinous processes of L2 and L3 lumbar vertebrae using an *in-plane* technique and its advancement was monitored with the probe. At the end of procedure, the catheter was removed. The piglets recovered from anaesthesia and were monitored for one week.

Results In phase I the authors identified the paramedian longitudinal approach as the most feasible for spinal structure evaluation in piglets. In phase II, the paramedian longitudinal views enabled a good visualization of the spinal cord and of the catheter advancement up to the *cisterna magna* in groups P7 and P14. In groups P21 and P28 it was not possible to visualize the neuroaxial structures and the spinal catheter using the same approach. No clinical alterations were recorded during the procedure or the following days.

Conclusions and clinical relevance US-guided spinal catheter placement appeared a feasible technique in piglets younger than 14 days but it is not useful in older piglets.

Keywords gene delivery, local anaesthesia, piglets, spinal catheter, ultrasound.

Introduction

The spinal anaesthetic technique in human medicine is reported to provide feasible analgesia for obstetric (Palmer 2010) or orthopaedic surgery (Gurlit et al. 2004). Spinal delivery is also used in neuroscience to deliver gene therapy with viral vectors in animal models (Federici et al. 2012).

Spinal catheter placement in piglets has already been described (Federici et al. 2012; Lambertini et al. 2015); however, in piglets younger than 1 month, the size of the anatomical structures makes this procedure challenging. In veterinary medicine, ultrasonography has been used as guidance for epidural puncture or catheter placement in dogs (Gregori et al. 2014; Viscasillas et al. 2014; Liotta et al. 2015; Viscasillas et al. 2016).

The aim of our study was to describe the ultrasonographic anatomy of the spinal cord and to investigate the use of ultrasound (US) guidance for spinal catheter placement in neonatal and newborn piglets. Moreover, the feasibility of the technique, the possibility of identifying the neuroaxial structures and, finally, whether visualization of the catheter along the spinal space up to the *cisterna magna* was possible were verified.

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Materials and methods

The study was divided into phase I (anatomical study on two piglet cadavers) and phase II (*in vivo* application of the technique in eight anaesthetised neonatal and newborn piglets).

The study was approved by the Ethics Committee of the University of Bologna in accordance with European Economic Community (EEC) Council Directive 86/609 adopted by the Italian Government (DL 27/01/1992 No. 116).

Phase I

A total of two commercial crossbreed piglet cadavers were considered for the US anatomical study. The piglets died in our facility from naturally occurring disease and were age 7 and 14 days, respectively.

The cadavers were used to carry out the US evaluation of the neuroaxial structure of the lumbar (L1−L7), thoracic (T1−T14) and cervical (C1−C7) tracts of the spinal cord using a 10 MHz linear probe (MyLab 5; Esaote, Italy). In both lateral and sternal recumbency, the operator carried out the evaluation by placing the probe in the median and paramedian position in both longitudinal and transverse views. The US images were recorded and stored for subsequent evaluation. The operator also evaluated which type of recumbency and view allowed better visualization of the neuroaxial structures.

Phase II

A total of eight commercial hybrid piglets were enrolled in the study; they were divided into four groups according to age: 7 (P7), 14 (P14), 21 (P21) and 28 (P28) days. The piglets were born in our facility and were control animals involved in research concerning gene delivery authorised by the Italian Ministry of Health. The piglets were housed in appropriately sized cages in accordance with standard operating procedures. The animals had never been used previously in an experiment.

The procedure was performed with piglets under general anaesthesia. The general anaesthesia was induced with sevoflurane (SevoFlo; Abbott Laboratories, IL, USA; end-tidal concentration, 2.3%) delivered in oxygen (50%) and air via a facemask while the piglet was held gently in the operator's arms. Soon after induction, endotracheal intubation was achieved and general anaesthesia was maintained with sevoflurane (end-tidal sevoflurane concentration, 2.3%) in oxygen and air. Complete cardiovascular monitoring was applied (S3; Datex-Ohmeda Inc., WI, USA). Prior to spinal catheter insertion, an US examination of the neuroaxial structures was performed using a 10 MHz linear probe. The spinal catheter insertion under US guidance was performed with the piglets in lateral recumbency using the paramedian approach with a longitudinal view, and the spinal catheter was placed as previously described in piglets (Lambertini et al. 2015) following a standard surgical approach. With the piglets in lateral recumbency and their hind limbs positioned forward, the operator introduced a 22 gauge 0.7 × 75mm spinal needle between the L2 and L3 lumbar vertebrae. The needle was inserted through the skin and up to the intrathecal space until cerebrospinal fluid (CSF) leakage was observed through the needle hub. During the needle placement, the operator felt the resistance encountered in its passage through the *ligamentum flavum* and loss of resistance (LOR) in its entrance into the epidural space. As previously described, the needle was removed and substituted with a 20 gauge 0.9 × 50 mm Tuohy needle (PERIFIXone; B-Braun, Germany). A 24 gauge spinal catheter (PERIFIXone; B-Braun) was then inserted through the Tuohy needle and advanced along the spinal space up to the *cisterna magna*. During the procedure, the US beam transducer was left in place and the needles were positioned using an *in-plane* technique. Multiple images of the tip of the spinal catheter were recorded at different points along the spinal tract in order to follow the catheter's advancement.

For each projection of each spinal tract, 10 images were recorded and stored for subsequent evaluation by the same anaesthetist who was experienced in the ultrasonography diagnostic techniques and aware of the age of the piglets. The evaluation was based on the visualization of the following landmarks: *ligamentum flavum*, *dura mater* and catheter tip. To define their visualization along the spinal tract, a descriptive scale, previously reported by Rapp et al. (2005) for the application of the same technique in children, was adopted. The 4-point scale ranged from 1 (excellent and clearly visible) to 4 (unrecognisable). The technique was considered feasible for each group of piglets if it was possible to visualize the catheter tip up to the *cisterna magna*.

At the end of the procedure, the spinal catheter was removed and the piglets were monitored until complete recovery and for one week to detect any neurological complications related to the procedure or any signs of pain.

