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SHORT COMMUNICATION

Ultrasound-guided vessel catheterization in adult Yorkshire cross-bred pigs

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Abstract

Objective To describe an ultrasound-guided approach for venous and arterial vascular access and catheterization in anesthetized adult Yorkshire cross-bred pigs.

Study design Prospective experimental study.

Animals Ten adult female Yorkshire cross-bred pigs, weighing 78.4 ± 5.6 kg (mean ± standard deviation).

Methods Using ultrasound guidance and the Seldinger technique, a 7 Fr, 20 cm triple-lumen central venous catheter was placed in the external jugular vein and an 18 gauge, 16 cm catheter was placed in the femoral artery. The success rate of catheterization and the incidence of catheter patency over 24 hours of general anesthesia were recorded.

Results Catheterization of the external jugular vein was successful in 10 out of 10 pigs and catheterization of the femoral artery was successful in eight out of 10 pigs. A surgical dissection technique on the femoral artery was performed in two pigs. Venous and arterial catheter patency was maintained in all pigs over the 24 hour study period.

Conclusions and clinical relevance Ultrasound guidance resulted in success rates of 100% for catheterization of the external jugular vein and 80% for catheterization of the femoral artery in anesthetized adult Yorkshire cross-bred pigs. This technique is a noninvasive, easily performed alternative to surgical exposure of the vessels in large pigs undergoing surgical instrumentation for biomedical device testing.

Keywords catheterization, pig, technique, ultrasound, vascular access.

Introduction

Catheterization of central veins is often necessary for studies requiring long-term administration of fluids and anesthetics, intravenous (IV) access for recurrent blood sampling, and central venous pressure (CVP) monitoring in pigs. Previous studies describe several nonsurgical techniques used for central venous catheterization in young pigs weighing <20 kg (Carroll et al. 1999; Fudge et al. 2002; Flournoy & Mani 2009). In larger pigs, catheterization of central veins is often performed by surgical exposure of the vessels. Subsequent surgical trauma may lead to a heightened inflammatory response, confounding the measurement of plasma concentrations of inflammatory cytokines, which was a critical component of the research study.

The utilization of ultrasound (US) to aid catheterization of central vessels has become the standard of

care in human medicine. In comparison with an anatomical, landmark-based approach, US guidance may decrease the number of attempts at catheter placement, avoid extravascular catheter placement and prevent injury to adjacent nerves and tissues (Randolph et al. 1996; Troianos et al. 1996; Gann & Sardi 2003). A method for US-guided percutaneous catheterization of the central veins of small pigs has been published, although the authors suggested that the technique might not be as effective in larger pigs (Brederlau et al. 2008).

The aim of this study was to describe an approach for catheterizing the external jugular vein and femoral artery using US guidance in anesthetized large (>70 kg) Yorkshire cross-bred pigs.

Materials and methods

Animals

Ten female adult, purpose-bred Yorkshire cross-bred pigs (*Sus scrofa domestica*) weighing 78.4 ± 5.6 kg (mean ± SD) were obtained from a commercial dealer (Animal Biotech Industries, Inc., PA, USA). The source herd is free from pseudorabies, brucellosis, salmonellosis, swine influenza virus and porcine respiratory and reproductive syndrome. The pigs were obtained for a research protocol involving a prolonged period of total IV anesthesia for extracorporeal life support (ECLS) device evaluation. All pigs underwent an acclimation period of 7 days before studies were initiated. All procedures were approved by the Institutional Animal Care and Use Committee of the Penn State University College of Medicine (protocol no. 44078).

Experimental preparation

The pigs were fasted for 16 hours with free access to water. Pigs were sedated with ketamine hydrochloride (20 mg kg^{-1}; Ketathesia; Henry Schein Animal Health, OH, USA), midazolam hydrochloride (0.5 mg kg^{-1}; Midazolam Injection, USP; Akorn, Inc., IL, USA) and acepromazine (1 mg kg^{-1}; Acepromazine Maleate Injection, USP; Vedco, Inc., MO, USA) administered intramuscularly in the same syringe. Pigs were administered 2–5% isoflurane (Isoflurane USP; Phoenix Pharmaceutical, MO, USA) via face mask to allow sufficient sedation for placement of an 18 gauge, 5.08 cm catheter (Safelet; Nipro Medical Corporation, FL, USA) in a caudal auricular vein. A ketamine–midazolam (8.3 and 0.5 mg kg^{-1} $hour^{-1}$, respectively) constant rate infusion (CRI) was then administered for maintenance of general anesthesia. These drugs were diluted together in a 500 mL bag of 0.9% NaCl and administered via an infusion pump (Heska Vet/IV 2.2; Heska Corporation, Israel). Following initiation of the ketamine–midazolam CRI, the pigs were intubated and 0.5–1% isoflurane was delivered in oxygen with mechanical ventilation (Dräger Fabius GS; Dräger Medical Inc., PA, USA) for supplemental anesthesia. Following placement of the external jugular vein catheter, CRIs of rocuronium (4–5 μg kg^{-1} $minute^{-1}$; Rocuronium Bromide Injection; APP Pharmaceuticals, LLC, IL, USA) and alfentanil (6 μg kg^{-1} $hour^{-1}$; Alfenta; Akorn, Inc., IL, USA) were administered for neuromuscular blockade and for supplemental analgesia, respectively. The ketamine–midazolam CRI was administered through the external jugular vein catheter and the auricular vein catheter was removed. Anesthesia monitoring included continuous electrocardiography, pulse oximetry, capnography, invasive blood pressure, CVP, and body temperature (SurgiVet Advisor Vital Signs Monitor; Smiths Medical ASD, Inc., MN, USA). Arterial blood gas and activated clotting time (ACT) measurements were performed hourly (VetScan iSTAT Handheld Analyzer; Abaxis, CA, USA). Thermal support was provided with a warm-water circulating blanket (Hot Dog Patient Warming System; Augustine Temperature Management, MN, USA). The pigs were anesthetized for 24 hours for evaluation of a novel pulsatile ECLS system.

Description of the US-guided technique

Pigs were placed in dorsal recumbency with the neck extended and the thoracic limbs retracted caudally. The jugular furrow and femoral triangle were clipped, aseptically prepared and draped. An 8 MHz US vascular probe (GE Vivid I; GE Medical Systems, Israel) coated with US lubricant (LiquaSonic Ultrasound Gel; Chester Packaging, LLC, OH, USA) was placed at an approximately 90° angle to the skin to locate the external jugular vein and femoral artery. The jugular vein was located approximately 2–3 cm deep to the skin. The jugular vein was differentiated from the internal carotid artery by manual compression of the tissues overlying the vessels using the vascular probe; the jugular vein was easily compressed using minimal pressure, whereas the internal carotid artery was less compressible. In the US view, the vein had thinner walls,

