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Motor Blockade by Brachial Plexus Block in the Sheep

Jean-Pierre Estebe, M.D., Pascal Le Corre, Pharm.D., Ph.D.,† François Chevanne, B.S.,‡ Guy Cathelineau, D.D., Ph.D.,§ Roger Le Verge, Pharm.D., Ph.D.,‖ Claude Ecoffey, M.D.#*

LABORATORY animal studies are necessary models for the assessment of new drugs and/or of drug delivery system used in regional anesthesia.[1-3] Few data are reported in the literature, excepted sciatic nerve blockade in rats. Therefore, the aim of this study was to evaluate the approach of the brachial plexus block in a sheep model using bupivacaine.

Materials and Methods

Sheep were chosen because they are comparable in size and weight to humans. Veterinary literature on the brachial plexus of sheep was studied to determine landmarks and to perform a comparison to humans.[4] Sheep have a postfixed brachial plexus (C6-T2), whereas humans have a prefixed brachial plexus (C5-T1). As with human nerve root organization, sheep nerve roots seem to be juxtaposed without interposition and are contained between scalenus muscles, suggesting a sheath existence. The phrenic nerve is innervated by C5-C8 cervical nerves, whereas the human phrenic nerve is innervated by C3-C5.

The study was approved by the Local Animal Research Committee. Twenty-three nonpregnant Lacaunes ewes (age, 3.5 ± 1 yr; weight, 68 ± 9.5 kg) were included in accordance with the rules and guidelines concerning the care and use of laboratory animals (Institut National de Recherche en Agronomie No. France 35 240 046). During general anesthesia (thiopental 5-8 mg/kg administered as an intravenous bolus) with the sheep lying on one side, the forelimbs were pulled caudally (neck axis, 110-120°), and the landmarks were determined. At the base of the neck, the surface landmarks were easily determined by means of palpation and examination: external jugular vein, cervical esophagus, and forward trachea; clavicle, transverse and descending pectoral muscles at the bottom; and scalenus ventralis, dorsalis muscles, and cervical vertebral column at the top.

Blocks were performed with electrical stimulation using a 50-mm insulated needle. The block needle was inserted just near the cervical vertebral column at the outer border of the scalenus ventralis muscle and then advanced caudally and dorsally toward the midpoint of the dorsal vertebral spine, along an oblique axis nearly parallel to the long axis of the sheep's neck and laterally with the plane of the operating table (fig. 1). When a forelimb or shoulder muscle response was elicited, the stimulation was decreased progressively. When muscle twitches were elicited with 0.5-mA impulses and just before appearance of animal spontaneous movements (usually 5-10 min after thiopental administration), drug solutions were injected over a 1-min period. In case of stimulation of the phrenic nerve (diaphragm contrac-

* Assistant Professor, Department of Anesthesiology and Intensive Care, Service d'Anesthésie Réanimation Chirurgicale 2.

† Assistant Professor, Department of Biopharmaceutics, Laboratoire de Pharmacie Galénique et Biopharmacie.

‡ Laboratory Technician, Laboratoire de Pharmacie Galénique et Biopharmacie.

§ Assistant Professor, Department of Dentistry, Laboratoire des Biomatériaux en Site Osseux.

‖ Professor, Department of Clinical Pharmacy, Laboratoire de Pharmacie Galénique et Biopharmacie.

Professor, Department of Anesthesiology and Intensive Care, Service d'Anesthésie Réanimation Chirurgicale 2.

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Address reprint requests to Dr. Estebe: Service d'Anesthésie Réanimation Chirurgicale 2, Hôpital Hôtel Dieu, 2 rue de l'Hôtel Dieu, 35000, Rennes, France. Address electronic mail to: jp6estebe@aol.com

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Table 1. Onset and Duration of Complete Motor Blockade (Level 3) after Injection of Different Bupivacaine Doses in Sheep Brachial Plexus (n = 3)

Dose of bupivacaine (mg)	Onset of motor block (min)	Duration of motor block (min)
37.5	0	0
75	35 ± 9	169 ± 60
150	11 ± 5*	200 ± 45
300	3 ± 1†	>300†

Mean (± SD).

* $P < 0.05$ between 75–150 mg.

† $P < 0.05$ between 150–300 mg.

tions), the needle was redirected gently downward, forming a 20–30° angle in relation to the plane of the operating table. Heart rate was recorded.

Nerve stimulation and injection of methylene blue was performed in two sheep that were killed 2 h later for postmortem anatomic control of setting injection.

The incidence of intrasheath injection was evaluated by the distribution of contrast medium by radiography. After nerve stimulation, various volumes were evaluated: 20, 30, and 40 ml (n = 3 for each volumes). Front and profile radiographs of the neck and shoulder region were taken.

After determination of a appropriate volume of injection, clinical evaluations were conducted with increasing doses of bupivacaine (37.5, 75, 150, and 300 mg) without epinephrine (n = 3 in each group). After recovery from brief anesthesia, motor blockade was evaluated using a modified scale of Bromage (level 0: free movements of the forelimb without limitation; level 1: limited or asymmetrical movement of forelimbs to support the body and walk; level 2: inability to support its own weight on forelimbs with detectable ability to move the forelimb; level 3: total paralysis).

Results are presented as mean ± SD. The Mann–Whitney U test for unpaired observations was used. Statistical significance was defined as $P < 0.05$.

Results

Twenty-three nerve stimulations were achieved by the same operator. The brachial plexus was reached in less than 5 min and within 5-cm depth (range, 1.5–4.5 cm). Inadvertent diaphragm contractions were observed in less than 15% of the nerve stimulations performed.

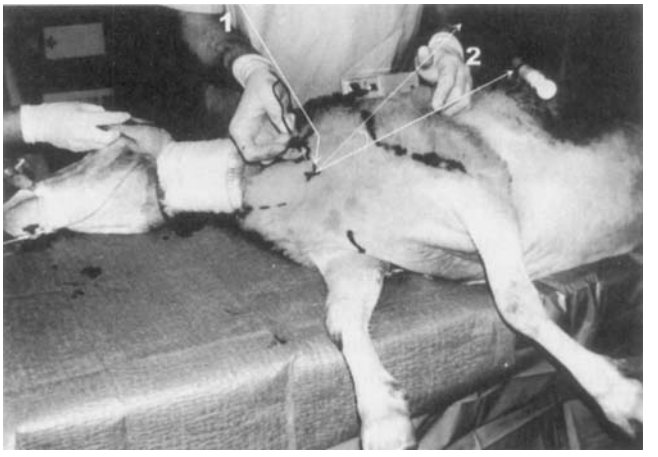

Fig. 1. During general anesthesia with the sheep lying on one side and the forelimbs lightly pulled caudally (neck axis, 110–120°) by a second investigator, the landmarks were determined. At the base of the neck, surface landmarks were easily determined by means of palpation and examination. The broken arrow (1) shows the entry site of the needle. The brachial plexus was identified using a nerve stimulator. The block needle was inserted and advanced caudally, dorsally toward the midpoint of the dorsal vertebral spine and along an oblique axis nearly parallel to the long axis of the sheep's neck and laterally with the plane of the operating table grossly visualized by angle (2).

Dissection of the sheep cadaver showed no visible vital structure in close proximity to the site of injection (vessels, lung, epidural space). The presence of methylene blue dye showed that the brachial plexus injection site was effective. Dissection records confirmed that the brachial plexus anatomy of sheep was close to that of humans.

Radiologic images with contrast medium for the brachial plexus compartment confirmed that the tapping location was accurate. An optimal distribution of contrast medium seemed to be obtained with 30-ml volume. A 20-ml volume seemed to give an incomplete spread. However, a volume of 40 ml led to a too-wide spread up to the epidural space. The spread of all injections seemed to be contained into a brachial plexus sheath.

Motor blockade was not observed with injections of contrast medium and methylene blue (n = 11). Usually, 1–2 min was sufficient to recover from anesthesia and to allow motor evaluation. The onset and duration of complete motor blockade after injection of different doses of bupivacaine is summarized in table 1. No apparent sign of cardiac or central nervous system toxicities were recorded with any dose (0.5–4.3 mg/kg). All animals demonstrated a complete recovery, and no sequelae were recorded.

Discussion

The aim of the present study was to evaluate the feasibility of brachial plexus block in a sheep model. Interscalene approach of brachial plexus block in sheep seemed to be an easy and reproducible technique. This approach used surface landmarks that provided an easily identifiable skin entry site. Our approach in the brachial plexus in sheep was closely related to the interscalene approach relevant to humans. It is likely that a sheath of brachial plexus exists (anatomic control, radiographic examination, and reproducible procedure of block). The 30-ml volume of injection seemed to provide an optimal spread of local anesthetics in the brachial plexus.

In conclusion, the brachial plexus block was performed easily in sheep and produced a motor block that varied in a dose-related fashion. This may be a useful model for assessing regional anesthesia of new drugs and/or new drug delivery system.

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