The Internet Journal of Anesthesiology
Volume 4 Number 3

Pneumatic Pulse Simulation In Cadavers For Teaching Peripheral Plexus Blocks

G Schwarz, R Kleinert, C Dorn, G Litscher, G Feigl, N Bock

Citation

G Schwarz, R Kleinert, C Dorn, G Litscher, G Feigl, N Bock. *Pneumatic Pulse Simulation In Cadavers For Teaching Peripheral Plexus Blocks*. The Internet Journal of Anesthesiology. 1999 Volume 4 Number 3.

Abstract

Arterial pulses are relevant anatomic landmarks for some of frequently used regional anesthetic blocks both for surgical procedures and pain therapy. We describe a compact and portable system to simulate regional pulses in cadav ers for teaching and training purposes. The system consists of an intraarter ial placed thrombectomy catheter connected to the extra-corporal component, a modified simulator for an infant respirator. The balloon of the catheter i s insufflated rhythmically to generate palpable pulses.

The system was studied in 12 cadavers (mean age 72.7 ± 8.8 years). Pulses we re generated in the axillary artery for the axillary region, the subclavian artery for the supraclavicular region, and the femoral artery for the subing uinal region. The pulsationes were registered by palpation and recording wit h an impedance system.

Artificial pulses were palpable in all 12 axillary arteries, in 10 of 12 sub clavian and femoral arteries and were recordable in 11 axillary, 7 subclavia n and 10 femoral arteries. Failure to palpate or record pulses was due to an atomic variants, arterial disease, induration of the skin, and lymphadenopat hy. The mean insufflation pressures required to generate an artificial pulse were significantly higher in the subclavian artery than in the axillary or femoral arteries (1.00 ± 0.13 vs. 0.80 ± 0.15 and 0.89 ± 0.09 bar, respectiv ely).

In conclusion, this system appears useful for training peripheral anesthetic block techniques.

INTRODUCTION

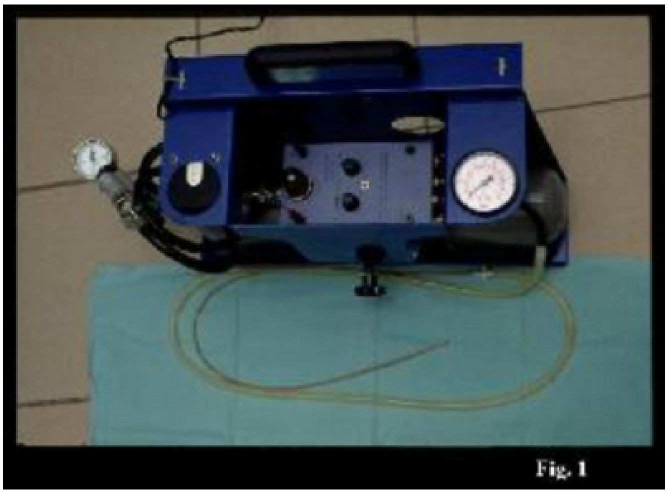
The practicing of procedures is a central component of medical training. Interactive computer simulations (1), training during cardiopulmonary resuscitation (2) and studying on human patient simulators (3) and cadavers (4) are procedures used to demonstrate and practice diagnostic and therapeutic interventions. For some regional anesthetic techniques, the regional artery is the landmark for placing the block. We designed a pneumatically driven, electronically controlled device to simulate regional arterial pulses in cadavers for training purposes. Artificial pulses were generated in the axillary artery for the axillary region, the subclavian artery for the supraclavicular region, and the femoral artery for the subinguinal region.

METHODS

This study was approved by the institutional ethic committee. The pulse simulator consists of an intracorporal balloon catheter connected to an extracorporal gas insufflation system. The catheter is an 80-cm, 8.0-French venous thrombectomy catheter (Fogarty(r), Baxter, USA) with a balloon with a maximum gas capacity of 8 mL. The extracorporal component is a modified simulator for an infant respirator (Dräger, Germany). We devised a carrying system that comprises additionally a 5-L bottle of pressurized oxygen or compressed air in a convenient, compact and portable unit (Fig. 1). Insufflation pressure was built up and relieved at a 3-valve socket to compensate for the resistance resulting from the length and narrow lumen of the catheter triggered by an electronic mechanism. This set-up permits insufflation and exsufflation cycles with continual expansion and collapse of the catheter balloon and continuous regulation of the insufflation pressure. The goal was to generate palpable and recordable pulses at the corresponding artery.

Figure 1

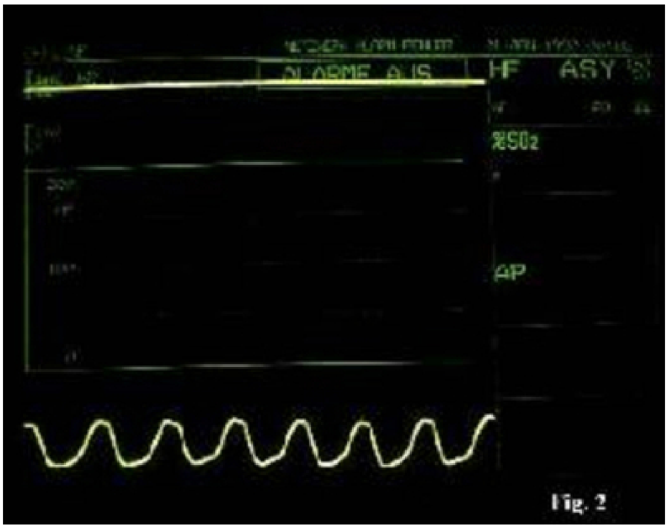
Fig. 1. Compact, portable pulse simulation system inclusive balloon catheter



The pulse simulator was evaluated in 12 cadavers (5 male, 7 female, mean age 72.7 ± 8.8 years) after autopsy 12-24 hours postmortem (Table 1). A 3-5 mm longitudinal incision was made over the cubital or popliteal joint to expose the brachial or popliteal artery. The catheter was inserted and connected to the gas insufflation device. The respective artery was palpated while the rhythmically expanding and collapsing balloon (frequency, 60/min) was placed at the desired position in the axillary, subclavian or femoral artery. The catheter was then secured with a suture and the skin closed with adhesive tape.

Figure 3

Fig. 2. Documentation of the artificial pulses (bottom of the screen) in the subclavian artery (supraclavicular) by impedance method



COPD=Chronic obstructive pulmonary disease

During puncturing the balloon was kept desuflated for a short periode to avoid the rapture of the balloon by malpositioning of the needle.

Pulsations were recorded (Fig. 2) with an adapted impedance registration device (Sirecust (r), Siemens, Germany). One of the three ECG electrodes was placed directly over the punctum maximum of the artificial pulse and the other electrodes over immobile adjacent skin regions (Fig. 3).

Figure 4

Fig. 3. Location of insertion of ballon catheter in right cubita

Figure 6

Fig. 4. Impedance registration system to record simulated pulses in the subclavian artery (supraclavicular)

The method was also tested by palpation in 7 preservated cadavers without intravasal application of dextrin gum meninge.

Data were analyzed with the Mann-Whitney rank sum test. A P value of <0.05 was considered statistically significant.

RESULTS

Artificial pulses were successfully palpated in all 12 axillary arteries, 10 subclavian arteries, and 10 femoral arteries. Electronic recording of the artificial pulses was successful in 11 axillary arteries, 10 subclavian arteries, and 10 femoral arteries (Table 2). In one cadaver palpation of the subinguinal region was limited by obesity, indurated skin, and gross lymphadenopathy due to malignant melanoma. In another cadaver an anatomic anomaly of the subclavian artery and stenosing sclerosis of the femoral artery prevented palpation of a pulse.

{image:5}

* Insufflation pressure necessary for recording of artifical arterial pulsations

The mean pressures (range 0.75 – 1.2 bar) required to generate a recordabel pulse in the respective arteries and the distances between the sites of insertion and palpation are shown in Table 2. The insufflation pressures necessary for recordable pulsations were significantly higher for the subclavian artery than for the axillary artery (P = 0.014) and nonsignificantly higher than for the femoral arteries (P = 0.169).

Despite of the reduced elasticity of tissue in preservated cadavers, the balloon oscillations were palpable in the axillary and subinguinal region in all 7 dead subjects.

{image:6}

DISCUSSION

Cadavers are irreplacable for teaching and studying anatomy (4,5), developing new medical techniques (6,7), and testing medical equipment (8). We and other institutions organize workshops with cadavers to demonstrate the anatomy relevant to regional anesthetic pain blocks. However, cadavers do not have the vital pulses that are the anatomic landmarks for determining the sites, direction, and depth of the needle used for block in clinical practice. This led us to develop a pulse simulator (see methods) for electronically triggered pneumatic expansion of the catheter balloon at typical points where arteries are palpated.

Palpation of the pulse of the major regional artery is particularly important for the subaxillary and supraclavicular blocks of the brachial plexus and the paravascular block of the lumbar plexus (3-in-1 block). In the axillary region, after separation of the fascicles of the brachial plexus under the musculus pectroralis minor, the radial, ulnar and median nerves are situated around the axillary artery. For the supraclavicular block of the brachial plexus it should be kept in mind that the three trunks of the brachial plexus are located dorsolateral to the subclavian artery in the lateral cervical region. The artery and the fascicles are enclosed in a common connective tissue sheath. In the subinguinal region the inguinal ligament and the femoral artery are the landmarks for the paravascular lumbar block (femoral nerve, lateral cutaneous femoral nerve, obturator nerve) (9, 10, 11, 12).

Simulated pulses generated by our device were palpable in all cases in the axillary region and in the large majority of cases in the supraclavicular and subinguinal regions. Reasons for failure of palpation of a pulse were anatomic anomalies, obesity, regional lymphadenopathy, and arteriosclerosis (Fig. 5).

Fig. 5. Incision of femoral artery. Note the calcificated plaque (arrow) and the desufflated balloon of the catheder in a subject where palpation of balloon oscillations was not possible.

The pressures required to insufflate the balloon of the catheter to generate a recordable pulse ranged from 0.75 to 1.2 bar and were significantly higher for the subclavian artery than for the axillary and femoral arteries, most likely because the subclavian artery lies under the clavicula and thus deeper than the other two. This is probably the reason why the superficial electrode was unable to detect the balloon oscillations. To avoid rupture of the balloon higher insufflation pressure should not be exeeded and furthermore during puncturing the balloon should be kept desufflated for a short period.

The palpation of the balloon oscillations was also possible in preservated cadavers ($_{13}$) without intravasal application of dextrin gum meninge.

In summary, our system for simulating arterial pulses in cadavers appears to be useful for training regional block techniques. The set-up is simple, easy to use, and minimally invasive. Costs can be limited by using used catheters and older, retired technical device. Failure rates can be reduced by selecting nonobese cadavers with no evidence of lymphadenopathy or peripheral artery disease.

References

1. Schwarz G, Pfurtscheller G, Litscher G, et al. Computer - controlled documentation of brain death in the intensive care unit. An�hesist 1993; 42 : 793-799
2. Kaldjian LC, Wu BJ, Jekel JF, et al. Insertion of femoral-vein catheters for practice by medical house officers during cardiopulmonary resuscitation. New Engl J 1999; 341/27: 2088 - 2091
3. Sanders J, Haas RE, Geisler M, et al. Using the human patient simulator to test the efficacy of an experimental emergency percutaneous transtracheal airway. Mil Med 1998; 163/8: 544-551
4. Mc Donald SW. Glasgow resurrectionist. Scott Med J 1997; 42/3: 84-87
5. Gordinier ME, Granai CD, Jackson ND et al. The effects of a course in cadaver dissection on resident knowledge of pelvic anatomy: an experimental study. Obstet gynecol 1995; 86/1: 137-139
6. Stankiewicz JA. Complication of endoscopic intranasal ethmoidectomy. Laryngoscope 1997; 97/11 : 1270-1273
7. Zerbino DD. The autopsy: its importance for modern clinical medicine. Lik Sprava 1992; 6: 3-9
8. Schwarz G, Litscher G, Kleinert R, et al. Cerebral oximetry in dead subjects. J Neurosurg Anesth 1996; 8/3 : 189-193
9. Thompson GE, Rorie DK. Functional anatomy of the brachial plexus sheath. Anesthesiology 1983; 59: 117-122
10. Brown DL, Cahill DR, Bridenbaugh LD. Supraclavicular nerve block: anatomic analysis of a method to prevent pneumothorax. Anesth Analg 1993, 76 (3) :530-4
11. Winnie AP, Ramamurthy S, Durrani Z. The inguinal paravascular technique of lumbar plexus anesthesia: the "3 in 1 - block" Anesth Analg Curr Res 1973, 52: 989-996
12. Hafferl A, Thiel W. Lehrbuch der topographischen Anatomie. 3th ed. Berlin Heidelberg New York: Springer, 1969
13. Thiel W. Die Konservierung ganzer Leichen in nat�en Farben. Ann Anatom 1992, 144: 185-195

Author Information

Gerhard Schwarz, M.D.
Department of Anesthesiology and Critical Care, University of Graz

Reinhold Kleinert, M.D.
Institute of Pathology, University of Graz

Christian Dorn, M.D.
Institute of Anatomy, University of Graz

Gerhard Litscher, Ph.D.
Department of Anesthesiology and Critical Care, University of Graz

Georg Feigl, M.D.
Institute of Anatomy, University of Graz

Norbert Bock, Ph.D.