Radionuclide-Anesthetic Flow Study: A New Technique for the Study of Regional Anesthesia

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A new technique to study the dynamics of in vivo distribution of regional anesthetics is described. Five hundred microcuries of technetium-99m diethylenetriamminepentaacetic acid (DTPA) added to the anesthetic in a syringe prior to injection allows both dynamic and static imaging to assess the initial distribution of the injected anesthetic. Superimposed bone scans or transmission scans help delineate anatomy. The radionuclide-anesthetic flow study is a simple, safe technique to investigate both the spread of regional anesthetics and the factors that affect it.

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Regional anesthesia is frequently employed perioperatively and in the pain clinic outpatient population. Common blocks include axillary, supraclavicular, and interscalene approaches to the brachial plexus and the stellate ganglion block. A newer technique is continuous intercostal infusion to control chest wall pain (*1*). Previous investigations employed in vivo contrast agent injections with postinjection radiographs or India ink injection in cadavers (*2–7*). We have reported a single case involving the study of flow during continuous intercostal infusion using a radioisotope technique (*8*). Subsequently, a variety of blockades have been studied with this technique and the investigation of the continuous intercostal blockade has been expanded. A safe, simple, inexpensive technique for the dynamic imaging of regional anesthetic distribution in vivo is presented.

MATERIALS AND METHODS

Five hundred microcuries of technetium-99m diethylenetriaminepentaacetic acid [^{99m}Tc]DTPA are mixed with the anesthetic solution in a syringe. Typically, a mixture of marcaine and lidocaine totaling 15–30 cc is used. As small a volume of DTPA as possible (0.1–0.25 cc) is added so that variations in anesthetic distribution are not related to volume of injectate. The mixture is injected in 3–4 divided doses of 5–10 cc each, with a 2–3 min pause between boluses. This technique allows for observation of the patient and any adverse reaction to the anesthetic. Complete resuscitation equipment is immediately available, as for all anesthetic administrations. All procedures are performed in standard fashion by trained anesthesiologists.

Posterior imaging with a large-field-of-view camera is employed for all of the blocks studied. High sensitivity collimation is used during dynamic imaging while high resolution collimation is reserved for postinjection static images. Patient positioning varies, depending on the anesthetic requirements of individual patients.

Both the continuous intercostal and continuous paravertebral techniques require the placement of a long "epidural" type catheter percutaneously in the posterior thorax. Long catheters are inserted on the ward prior to transport of the patient to the nuclear medicine clinic. This type of catheter allows injection and imaging of the patient in the supine position, and facilitates repeat anesthetic administrations.

Concomitant bone scanning is often useful, as the ribs provide an excellent marker against which to gauge the spread of the anesthetic. Rib visualization also allows for correlation with the dermatomal distribution of analgesia. For optimal imaging, a dose of 20 mCi of ^{99m}-Tc methylene diphosphonate is administered 3–4 hr prior to the anesthetic study. Either a single high count static or multiple 5–10 sec dynamic 64 × 64 byte images are obtained with the patient supine. Subsequently, a dynamic study is acquired, also in a 64 × 64 byte matrix, as the anesthetic is injected.

For axillary and scalene blocks, transmission scans provide adequate anatomic localization of the anesthetic, eliminating

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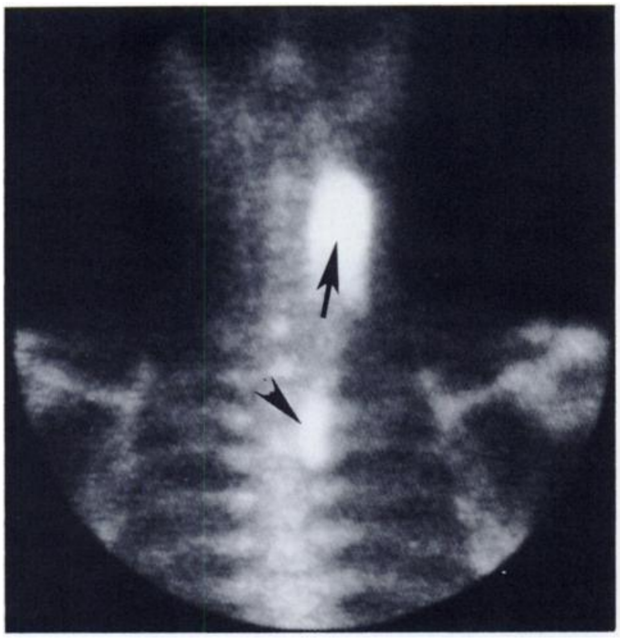

FIGURE 1
Stellate ganglion block. Posterior image of cervical and upper thoracic spine. Arrow indicates injection site and area of primary distribution of anesthetic. Arrow head denotes caudal extension of anesthetic mixture to level of T_3. This extension occurred rapidly during initial injection and represents a small "pocket" of anesthetic/radionuclide mixture that dissected through fascial planes

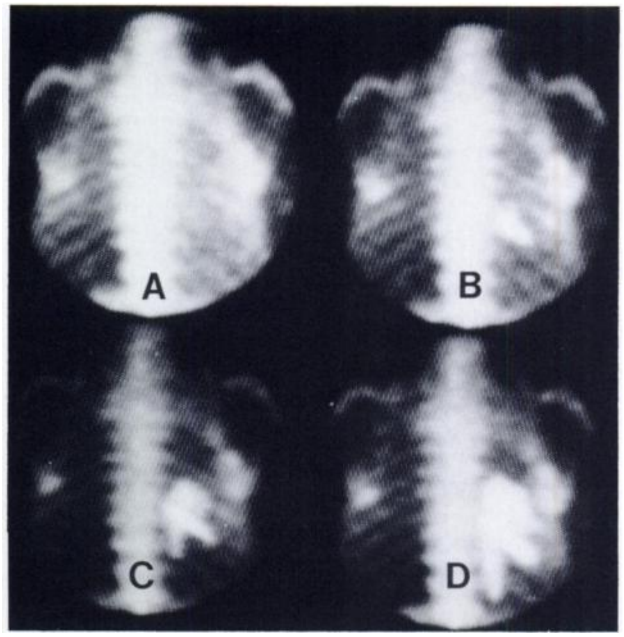

FIGURE 2
Four representative images from continuous intercostal infusion study performed with concomitant bone scanning. Patient had undergone right thoracotomy for open lung biopsy. (A) Posterior view, pre-injection. (B) Initial 10-cc bolus. (C) After third 10-cc bolus. (D) Immediately postinfusion, final distribution. Note spread of anesthetic/radionuclide mixture over seven intercostal spaces (dermatomes). Quality of pain relief is enhanced when multiple dermatomes are blocked

the need for bone scanning. The transmission scans may be obtained either before or after injection of the anesthetic, and the patient must remain motionless throughout the study.

The data are processed by masking the dynamic series with transmission scans or pre-injection bone images. The mask images have a much greater count density than the dynamic images, and require division by a constant before addition to the dynamic series. Smoothing of the final series enhances scan appearance. These techniques allow for dynamic display of the spread of the anesthetic and good delineation of local anatomy. High resolution, 256 × 256 byte static images may be obtained postinjection in posterior, lateral, and oblique positions as necessary to provide better anatomic localization.

RESULTS

Representative images from a stellate ganglion injection and a continuous intercostal study are shown in Figs. 1 and 2. Figure 3 shows anesthetic distribution after axillary blockade in two different patients. Investigation of a variety of blocks with no adverse effects and excellent patient acceptance has been accomplished. We have studied the continuous blockade techniques more extensively than other regional blocks. Our data indicate that the intercostal technique is less reproducible than the paravertebral approach. Physical interventions, such as active movement of the ipsilateral extremity postinjection, enhance the spread of the anesthetic over a greater area. This simple expedient improves the anesthetic outcome. These new findings, as well as correlation of imaging with clinical extent of analgesia, are being reported in detail separately.

DISCUSSION

Because the anesthetics and the DTPA are both water soluble and well-mixed, the initial distribution of the DTPA reflects the initial distribution of the anesthetic. Subsequent rates of diffusion from the site of injection for DTPA and the anesthetic agents may be different due to differences in molecular size, charge, and biochemical interaction. Thus, washout imaging is not feasible with this technique.

The radionuclide-anesthetic flow study is a simple, safe, and useful technique with which to study factors influencing the distribution of regional anesthetics in vivo. Advantages over other techniques include a low radiation burden, no risk of contrast reaction, and the ability to perform dynamic imaging. The assessment of anesthetic distribution in actual patients is clearly more physiologic than cadaver studies. This technique will allow direct comparison of standard and newly developed approaches to analgesia, without the necessity of relying solely on subjective patient responses to pinprick tests. The reproducibility of any given regional anesthetic approach can be evaluated in vivo. The technique

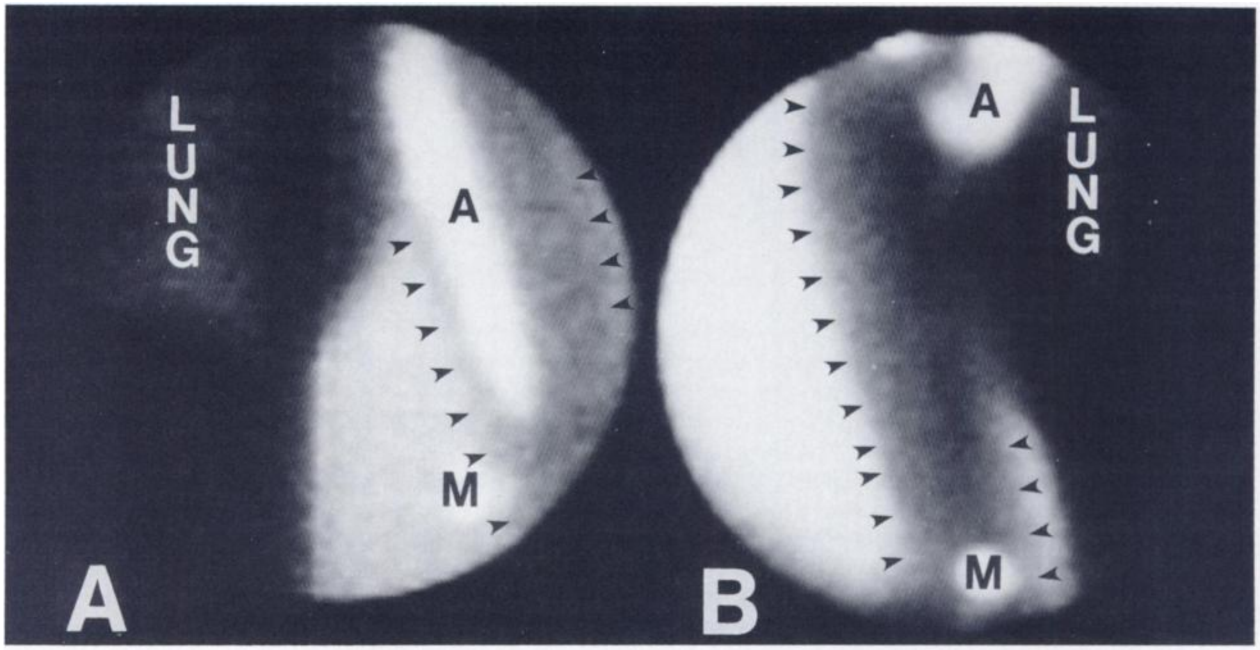

FIGURE 3
Axillary blockade studies in two different patients, demonstrating use of transmission scanning. Arrowheads outline medial and lateral aspects of arm in each image. (A) Posterior view, right axilla and arm. Patient was injected without application of manual pressure distal to injection site in axilla. Anesthetic (A) spread freely and rapidly to the antecubital fossa, shown by a marker at (M). (B) Posterior view, left axilla and arm. Image labels are same as in (A). Note that anesthetic/radionuclide activity is confined to injection site in axilla. In this case distal pressure was applied during injection. Manual compression is effective in limiting anesthetic flow away from its intended site of action

may also be useful in training anesthesiologists, and in evaluating "problem cases" when the expected analgesic result is not obtained. The effects of physical interventions such as tourniquet placement, physical activity, and alterations in volume of injectate may now be compared objectively in order to develop optimal regional anesthetic techniques.

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