VESSEL oil intoxication is a known cause of exogenous lipid pneumonia. Vaseline oil is a mixture of saturated aliphatic (C14–C18) and cyclic hydrocarbons that is insoluble in water and, in the alveolar space, activates an acute inflammatory response with edema and interstitial fibrosis. Because the hydrocarbons cannot be metabolized in humans, the therapy consists of limiting or decreasing the inflammatory reaction by steroids or of removing the hydrocarbons. The success of the two approaches depends on the extent of the intoxication, but unfortunately, no quantitative measurements of hydrocarbons are available in the literature. We report a case in which we quantitatively assessed the hydrocarbon lung concentrations during treatment.

Case Report

A 44-yr-old woman with schizophrenia (medical history otherwise negative) was admitted to the intensive care unit with acute respiratory distress syndrome. Mechanical ventilation was started. Positive end-expiratory pressure, 15 cm H2O, resulted in a marked improvement in oxygen fraction ratio from 107 to 560 (Pao2 = 0.7), Paco2 from 45.9 mmHg to 41.6 mmHg, and respiratory compliance from 46.7 to 60.9 ml/cm H2O. The patient was initially given wide-spectrum antibiotics, which were discontinued after 4 days because microbiologic cultures of tracheal aspirate, bronchoalveolar lavage fluid, blood, and urine were negative and remained negative throughout the clinical course. Vaseline oil intoxication was diagnosed on day 2, and methylprednisolone was given (2 mg · kg−1 · day−1). The severe respiratory failure steadily improved for 20 days, but when we discontinued methylprednisolone on day 29 gas exchange deteriorated, and the patient became hemodynamically unstable and presented septic shock without infection. Methylprednisolone was restarted (2 mg · kg−1 · day−1 on day 30), with improvement of hemodynamics and respiratory function. However, a subsequent attempt to taper the methylprednisolone to 0.25 mg · kg−1 · day−1 on day 44 again resulted in deterioration. The quantitative analysis results of a lung computed tomographic (CT) scan taken on day 46 were nearly identical to those of the scan taken on day 1 (fig. 1). We measured the

Vaseline oil concentration in the lung secretions by nuclear magnetic resonance and infrared spectrometry, and we found a concentration of 44 mg/ml (no data are available in the literature for comparison). Because the steroid therapy had failed to cure the disease and because we felt that it was unlikely that isotonic saline would remove the immiscible oil, we looked for an agent that could be added to the lavage solution to facilitate removal of the hydrocarbons.

After several in vitro tests (see Discussion), we concluded that the best agent to emulsify the oil secretions in the lung was a solution of 0.05% polysorbate 80 in Ringer’s lactate, and we proposed this solution for lung lavage.

On day 49, the lungs were separated with a double-lumen tube, and the patient was placed in the lateral decubitus position. After ventilation with 100% oxygen, the nondependent right lung was filled by gravity (+40 cm H2O), with the solution noted, nearly twice the lung gas volume (measured with the helium dilution technique), at a temperature of 37°C. Manual percussion of the hemithorax was performed to facilitate mixing. After 15 min, the fluid was drained. During this time, the dependent lung was ventilated with an Fio2 = 0.9 and tidal volume and respiratory rate set to maintain normocapnia with a plateau pressure below 30 cm H2O. Repeated lavages were performed until the effluent solution from the lung appeared to be free of lipid. This required 15–20 procedures, and the cumulative lavage volume was approximately 20 l/lung. The lavage balance (input minus output) was close to zero. After the lavage, 250 mg pig’s surfactant was instilled in each lobe. The entire procedure was repeated on day 50 for the left lung. Gas exchange and hemodynamics were stable during the lavage. The concentration of oil in the lung secretions on day 51 was 4 mg/ml 10 times lower than at the start. A whole-lung CT scan on day 55 showed marked improvement in lung aeration (fig. 1). An additional lung lavage (days 67–68) did not provide any further advantage, and the oil concentration was 3.8 mg/ml.

Respiratory function improved rapidly, and the patient was successfully weaned from mechanical ventilation and discharged from the intensive care unit. After a month’s rehabilitation, the patient had an oxygen fraction ratio of 371. A vital capacity 83% of predicted, a ratio of the forced expiratory volume in the first second to forced vital capacity of 82% of predicted, and a carbon dioxide diffusion capacity of 26%. A high-resolution lung CT scan showed the persistence of diffuse ground-glass opacification, more marked in the lower lobes.

Fig. 1. Computed tomographic scans taken at patient’s admission, before lung lavage, and after lung lavage. Quantitative analysis and visual analysis show that scans at admission and before lavage are nearly identical. After lavage, lung edema and nonaerated fraction of lung parenchyma decreased substantially.
Discussion

Exogenous lipid pneumonia was suspected at admission on the basis of the patient’s history. She had been using one or more 200-ml packs of vaseline oil per day, even though the maximal laxative dose was 45 ml/day. Although lung injury has been described after mineral oil inhalation, in this case, we could not exclude a role of intestinal absorption (normally approximately 2%7) because the homogeneous lung parenchyma alteration (fig. 1) seemed more typical of a lesion arising through the bloodstream. The idea of lipid pneumonia was confirmed by lipid-laden macrophages with oil drops on the surface of the fluid in the bronchoalveolar lavage and was subsequently confirmed by the coincidence of nuclear magnetic resonance and infrared spectra with those of the oil the patient had been taking.

Whatever the pathway by which the oil reaches the lung parenchyma, it either is absorbed by alveolar macrophages or remains free within the alveoli.9 Because alveolar macrophages cannot metabolize it, when they die, the oil is released again into the alveoli.9 In our patient, microscopic examination of fluid from sequential bronchoalveolar lavages clearly supported this because there was a cycle of intracellular oil (day 2), extracellular (day 6), intracellular (day 40), and then extracellular again. Quantitative analysis of the CT scan (day 1) showed a lung weight of 2,101.00 g with an excess tissue mass of 1,311.26 g (261.18%). The normally aerated fraction of the lung parenchyma was only 5%. In typical acute respiratory distress syndrome, these values are associated with low respiratory system compliance (< 20 ml/cm H2O),10 but in this case, it was higher than expected—60 ml/cm H2O—and the lung showed an impressive opening capability (at 45 cm H2O airway pressure, the normally aerated tissue increased from 5% to 74%). This can be partially explained by the presence of vaseline oil at the gas–liquid interface acting as surfactant (surface tension: 35 dyn/cm vaseline oil, 70 dyn/cm water, 25 dyn/cm normal surfactant film).

Steroids are suggested for the treatment of lipid pneumonia and have proved successful in some cases, but likely depending on the degree of intoxication. In this patient, the mineral oil concentration was 44 mg/ml. Unfortunately, no comparative data are available in the literature. At this degree of intoxication, steroids seem to control but do not solve the inflammatory response, as confirmed by the finding that after 46 days, the CT scan was similar to the initial scan, and the mineral oil was still being recycled (intracellularly and extracellularly) in the alveolar space.

We then decided on lung lavage, preparing different solutions to remove immiscible vaseline oil. We found that possible solutions adequate to emulsify, in vitro, a mixture of saline and lung secretions in a ratio 1:1 or a mixture of saline and vaseline oil at 44 mg/ml required 40–80 mg/ml phospholipids (first solution), 625 mg/ml citicoline (second solution), or 0.5 mg/ml sorbitol monoooleate (polysorbate 80) (third solution). To prepare a 40-lavage solution (20 l/lung), the cost of the first solution would have been exorbitant, and the second solution would have resulted in hyperosmolarity. The third solution (0.5 mg/ml of polysorbate 80), however, seemed both reasonable and inexpensive. Although polysorbate 80 has apparently not been used for lung lavage in patients, it is an emulsifying agent found in several medications for enteral, parenteral, or inhalational administration as a calyptol inhalant and fluibutason propionate, and the amount we used was below the maximal recommended daily dose (25 mg/kg).

In conclusion, this case taught us that steroids seem to control but do not solve the inflammatory response, at least for this degree of intoxication, and that lung lavage with polysorbate 80, in this patient, was safe and effective.

References

A LARGE dose and volume of anesthetic are important determinants of successful brachial plexus block using a nerve stimulator. Therefore, bilateral brachial plexus blocks are rarely performed because of fear of systemic local anesthetic toxicity. Ultrasound guidance helps to visualize the cords of the brachial plexus so that the anesthetic may be deposited precisely, making it possible to perform blocks with low doses of anesthetic agents. We report a series of successful simultaneous bilateral infraclavicular brachial plexus blocks using low doses of lidocaine for surgery of both arms.

**Case Report**

The patients were premedicated with 2 ± 1 mg midazolam and 50 ± 25 μg fentanyl. The arms were abducted to 90°. The deltopectoral areas on both sides were scanned for the optimal image with a 4- to 7-MHz C 11 curvilinear probe (Sonosite, Bothell, WA), and the outline of the probe was marked at each site. The entire upper chest was prepared with Betadine and draped in a single field. The technique used in this case has been described in detail, except that a smaller volume of anesthetic was used. The medial, lateral, and posterior cords were imaged (fig. 1), and after placing a 17-gauge Tuohy needle close to each cord, 1 ml local anesthetic was injected to confirm its location, and then 3–5 ml more of the solution was injected as the anesthetic dose. The endpoint of injection was spread of local anesthetic on all sides of each cord as visualized by real-time sonography. The block was administered on each side using approximately 20 ml lidocaine, 2%, with sodium bicarbonate (0.9 mEq/10 ml) and epinephrine, 1:200,000 (LES). A 19-gauge Flextip catheter (Arrow, Reading, PA) was placed between the axillary artery and the posterior cord (fig. 2). The position of the catheter tip is not always apparent on the ultrasound monitor; it can be confirmed by injection of 1–2 ml air (fig. 3). The procedure was repeated on the opposite side using the same technique.

All blocks were performed by residents with an attending anesthesiologist holding the probe and were successful. The demographics and other details are shown in table 1. After completion of the procedure, the catheter was looped near its skin entry site and covered with a transparent dressing. The dressing should be placed cephalad on the site so that the spread of local anesthetic agent injected through the catheter can be observed by ultrasonography without removing the dressing, which may compromise the quality of the image.

**Discussion**

Fear of toxicity prevents the simultaneous use of regional anesthesia at more than one site. A recent case report by Maurer et al. describes bilateral brachial blocks using an interscalene approach on one side and an infraclavicular approach on the contralateral side. The authors were concerned about the systemic toxicity of ropivacaine; therefore, they used 35 ml ropivacaine on each side instead of their usual 40 ml. They did not want...
to decrease the dose further for fear of block failure. Their concern about toxicity also made them delay for 20 min between doses to separate the peaks of absorption of the anesthetic. This is important for safety but may prolong the anesthesia preparation time and delay surgery. They also used a propofol infusion to increase the seizure threshold. Our experience of successfully using doses as low as 14 ml LES permitted us to perform bilateral brachial blocks safely. Simultaneous administration in all but one patient decreased the time required and permitted us to use the same needles and sonography probe for both blocks.

This technique should ideally be used in relatively short procedures, because 20 ml can be expected to last only 1.5–2.5 h in our experience. In longer operations, anesthesia can be successfully extended by injecting the agent through the catheter, as in cases 6 and 8. The

Table 1. Patient Demographics and Amount of Local Anesthetic Used

<table>
<thead>
<tr>
<th>Case No</th>
<th>Age, yr/Sex</th>
<th>ASA PS</th>
<th>Weight, kg</th>
<th>Indication</th>
<th>Initial Volume LES</th>
<th>Subsequent Bolus of LES</th>
<th>Duration of Surgery, min</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71/M</td>
<td>III E</td>
<td>80</td>
<td>Incision and drainage abscesses, right hand and left arm</td>
<td>20 ml on each side</td>
<td>None</td>
<td>65</td>
<td>Right catheter was used for postoperative pain; successful 2nd surgery by inducing infraclavicular block through catheter. Simultaneous femoral and infraclavicular block for 3rd surgery.</td>
</tr>
<tr>
<td>2</td>
<td>42/M</td>
<td>I E</td>
<td>79</td>
<td>Completion amputation of multiple digits, both hands</td>
<td>20 ml on each side</td>
<td>None</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>16/M</td>
<td>I E</td>
<td>56</td>
<td>ORIF fracture, right arm; repair of structures, left arm</td>
<td>20 ml on each side</td>
<td>None</td>
<td>108</td>
<td>Catheter was used for postoperative pain control. Catheter was used for postoperative pain control.</td>
</tr>
<tr>
<td>4</td>
<td>62/F</td>
<td>II E</td>
<td>68</td>
<td>Excision of multiple lipomas, both arms</td>
<td>20 ml on each side</td>
<td>None</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>35/M</td>
<td>III E</td>
<td>75</td>
<td>Creation of AV graft, right arm; excision of thrombosed AV graft, left arm</td>
<td>Right side: 36 ml LES; left side: 20 ml chloroprocaine</td>
<td>None</td>
<td>123</td>
<td>Initially, unilateral surgery was planned. Later, surgeon requested to operate on the left arm.</td>
</tr>
<tr>
<td>6</td>
<td>39/M</td>
<td>II E</td>
<td>63</td>
<td>ORIF fracture, both bones, left arm and right metacarpal</td>
<td>20 ml on each side initial dose</td>
<td>Left side: 35 ml (10, 10, 5, 5, 5 ml at 2, 3, 3.5, 4.5, 5.5 h, respectively); right side: 45 ml (20, 5, 10, 5, 5 ml at 3.5, 5, 5.5, 6.5, 7 h, respectively)</td>
<td>450</td>
<td>Propofol sedation started after 5 h.</td>
</tr>
<tr>
<td>7</td>
<td>40, M</td>
<td>II E</td>
<td>80</td>
<td>Débridement of recurrent frostbites, both hands</td>
<td>20 ml on each side</td>
<td>None</td>
<td>20</td>
<td>Catheter was requested and used for pain control and vasodilatation. Propofol infusion started after 4.5 h.</td>
</tr>
<tr>
<td>8</td>
<td>69/M</td>
<td>II E</td>
<td>81</td>
<td>ORIF right ulnar fracture; ORIF left 2nd, 3rd, 5th metacarpal fracture</td>
<td>20 ml on each side</td>
<td>Left side: 20 ml (10, 10 ml at 2.25, 3.45 h, respectively); right side: 20 ml (10, 10 ml at 3, 4.5 h, respectively)</td>
<td>306</td>
<td></td>
</tr>
</tbody>
</table>

ASA PS = American Society of Anesthesiologists physical status; AV = arteriovenous; LES = 2% lidocaine with 1:200,000 epinephrine and 1/10 ml sodium bicarbonate solution; ORIF = open reduction and internal fixation.
patient may become uncomfortable with prolonged immobility during an extensive procedure; low-dose propofol (10–25 μg · kg⁻¹ · min⁻¹) may be given for sedation. Propofol was used in only two patients despite successful sensorimotor block, after 4.5 and 5 h. To the best of our knowledge, there are no data on which to base the administration of additional doses of local anesthetic; we gave repeat injections relatively frequently (case 6). The block in this patient had partially dissipated by 2 h; 20 ml anesthetic through the catheter 3.5 h after the initial dose restored complete blockade. Further studies are needed to determine the optimal maintenance dose and its timing.

Catheters were placed with ultrasound guidance to supplement the anesthetic if the blocks were patchy or to prolong the duration of anesthesia if necessary. They may be used for prolonged periods as needed for pain relief, subsequent surgery, or sympathectomy for revascularized digits. In case 1, a larger volume (30 ml) of LES was used through the catheter for a second procedure, because the anesthetic had to spread to all of the cords from a single point, instead of the multiple injection sites used for the patient’s first surgery.

Our patients were highly satisfied with their anesthetics. Patients 1, 5, and 7 had undergone infracavicular blocks on previous occasions and subsequently requested another brachial plexus block. The use of ultrasound also significantly improves the quality of the nerve blocks, making it possible to use regional anesthesia simultaneously in different areas of the body. Marhofer et al. approached the femoral nerve with the needle aligned parallel to its longitudinal axis. We approach both femoral and infracavicular nerves at a right angle, with the nerve imaged in transverse section. This has several theoretical advantages: Nerves have more side-to-side mobility and may be displaced more with the block needle (because they are difficult to stretch lengthwise), and the needle, several nerves, blood vessels, and the spread of local anesthetic can all be viewed simultaneously in a single view, thus preventing nerve injuries and improving the quality of the block. Ultrasonography can also detect intravascular placement of the needle, and hence virtually eliminates the possibility of toxic reactions. The use of catheters adjacent to the nerves eliminates the need for analgesics in the recovery room and also provides excellent pain relief in the postoperative period. None of our patients requested any analgesics, and all had low pain and sedation scores in the recovery room. Patients can even be sent home using a bupivacaine infusion or given a bolus of the anesthetic before discharge, providing pain relief for 8–12 h. Pericatheter leaks are rare with the ultrasound-guided technique because the needle is redirected through the tissues several times during its advance; when it is withdrawn, the tissue planes resume their natural positions, and the resultant catheter path has multiple curves.

In conclusion, ultrasound-guided bilateral infracavicular blocks provide safe and effective anesthesia with half of the conventionally used 40-ml doses, resulting in superior intraoperative and postoperative analgesia, and can be used as an alternative to general anesthesia.

The authors thank Sanford Miller, M.D. (Clinical Associate Professor of Anesthesiology, New York University School of Medicine, and Assistant Director, Department of Anesthesiology, Bellevue Hospital Center, New York, New York), for editing the manuscript.

References