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Regional Anesthesia in Austere Environments

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Military anesthesiologists must master the complexities of modern anesthesia at home, like their civilian counterparts, and also be prepared to provide effective, safe anesthesia in the chaotic and austere environment of the modern battlefield. This article describes the Army Regional Anesthesia Initiative and Operational Anesthesia Rotation programs designed to facilitate this difficult goal. *Reg Anesth Pain Med 2003;28:321-327.*

Key Words: Regional anesthesia, Austere environments, Military anesthesia, Regional anesthesia training.

Anesthesiologists in the United States military are called on to provide anesthesia in austere environments in times of war. In the United States, the modern infrastructure of roads, hospitals, and sophisticated medical technology allow anesthesiologists to focus tremendous resources on the care of comparatively few patients at one time. On the modern battlefield, anesthesia providers are often confronted with the reverse situation, little or no infrastructure, a small resource base, and large numbers of casualties over a short period of time in hostile or dangerous areas. In the classic military logistics equation of beans, bullets, and Band-Aids®, the first 2 necessities of warfare (food and ammunition) can place severe limitations on the availability of medical resources. The military anesthesiologist is confronted with the daunting task of providing quality care for numerous casualties in an environment of limited logistical support. In addition, the military resident must gain anesthesia proficiency and develop an understanding of both the military environment and military medical readiness.

Military medical readiness for the military anesthesiologist must go beyond wearing a uniform or being physically fit. True medical readiness implies that an anesthesiologist possesses the skills and knowledge to perform anesthesia for any mission, anytime, anywhere.[1] To achieve this goal, military planners are particularly interested in techniques that are "field friendly," requiring minimal logistical support while providing quality anesthesia and analgesia on the battlefield. Regional anesthesia (RA) has characteristics that fulfill many of these requirements, and RA has shown its utility in past military conflicts.[2] Although the military anesthesiologist will retain the capability to perform general anesthesia (GA) on the modern battlefield, the need for frequent compressed gas resupply, ventilators, and dependable sources of electricity make GA more difficult to support logistically. This article will describe the Army's Regional Anesthesia Initiative for military anesthesiology residents and discuss the advantages of RA in austere environments. The value of medical missions abroad in austere locations as a training model for anesthesia on the battlefield will also be discussed.

Because weapons of modern warfare have become increasingly lethal, the makeup of battlefield casualties has changed. Generally, wounds of the head or thorax tend to be lethal, whereas superficial wounds or wounds to the extremities tend to be survivable. Data from the Wound Data and Munitions Effectiveness Team, a database of approximately 8,000 United States soldiers wounded during an 18-month period from 1967 to 1969 in Vietnam, support this assertion.[3] Two thirds of the fatally wounded soldiers had wounds of the head or chest, whereas three fourths of the surviving soldiers had soft-tissue or extremity wounds. Two thirds of the surgeries performed on combat casualties were soft-tissue wounds and extremity fractures. Anecdotal reports from the recent conflicts in Afghanistan and Iraq continue to support this observation. Advances in helmet and body armor have further reduced penetrating head and thorax injuries but not extremity injuries.[4] Although military anesthesiologists will always require the

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Table 1. Advantages of Regional Anesthesia on the Modern Battlefield

Excellent operating conditions
Profound perioperative analgesia
Stable hemodynamics
Limb specific anesthesia
Reduced need for other anesthetics
Improved postoperative alertness
Minimal side effects
Rapid recovery from anesthesia
Simple, easily transported equipment required

equipment and training to perform GA extremity wounds, the most survivable will predominate.

RA is well suited for the management of these injuries either as an adjunct to GA or as the primary anesthetic.[5] Potential advantages of RA on the modern battlefield are listed in Table 1. One particular advantage of RA compared with GA is rapid recovery and the ability to protect the airway. The use of GA as the primary anesthetic, and the increased incidence of postoperative nausea and vomiting, drowsiness, and pain associated with GA, are the most frequent causes of prolonged postoperative stay after ambulatory surgery.[6,7] In a field environment, availability of suction, oxygen, and antiemetic medications is limited. The advantages of RA have economic significance in civilian hospitals but could be lifesaving in the chaotic battlefield environment. Rapid recovery will allow the soldier to be an active participant in his evacuation and reduce the number of medical personnel needed to manage the postoperative recovery area. In addition, the profound analgesia could possibly reduce opioid use in mass casualty situations in which adequate monitoring is difficult and medical personnel are limited. Continuous peripheral nerve block (CPNB) could further extend the benefits of RA into postoperative recovery as the soldier is evacuated. Often CPNB can be used repeatedly to reestablish surgical blocks when multiple operations are required. These characteristics make RA on the battlefield a medical "force multiplier," providing the military anesthesiologist with a powerful tool to enhance anesthesia and analgesia throughout a soldier's treatment.

Army Regional Anesthesia Initiative

Despite the military benefits of RA, there is a paucity of experienced regional anesthesiologists in the Army. The Army's anesthesia programs, like most training programs in the United States, provide adequate training in traditional neuraxial RA techniques but do not provide sufficient focus on peripheral nerve block (PNB) or CPNB.[8,9] To improve Army RA training and develop RA as a battlefield anesthetic, the anesthesiology consultant to the surgeon general, Colonel John H. Chiles, made RA a training priority. To achieve this mission, a multifaceted program was developed, the Army Regional Anesthesia Initiative (ARAI). Its principle goal is the continued development of RA in the management of acute pain in patients at home and on the battlefield. Anticipated outcomes of this initiative are listed in Table 2. To this end, initial efforts have been directed at establishing a core of fellowship trained regional anesthesiologists from recognized centers of RA expertise. These trained individuals then serve as directors of regional anesthesia sections in the Army's residency programs and faculty at the annual Comprehensive Regional Anesthesia Course. Regional anesthesia training at Walter Reed Army Medical Center (WRAMC) is centered on the regional anesthesia section that consists of 4 induction areas outside of the operating rooms. Surgical cases that can be performed under RA are assigned to the block team consisting of a senior anesthesiology resident and a staff anesthesiologist with expertise in RA (sedation and monitoring in the operating room is handled by another anesthesia provider). This system facilitates resident training in RA, enhances the physician-anesthesiologist relationship, and does not impact on operating room case times because most blocks are finished before completion of the preceding case. Since we have started the ARAI, the numbers of peripheral nerve blocks our residents perform yearly has increased over 650% (Table 3).

A second focus of Army anesthesiology residency training at WRAMC has been the Operational Anesthesia Rotation (OAR). The one-month rotation consists of planning and deployment on a 2-week operational anesthesia mission in an austere environment. Residents are accompanied and supervised by a staff anesthesiologist with experience in field medicine. This program is designed to introduce basic concepts in preparation and implementation of anesthesia care in environments with poor infrastructure and resources. Objectives of the program are provided in Table 4.

Table 2. Army Regional Anesthesia Initiative (ARAI) Anticipated Outcomes

Improved RA training of our military anesthesiologists (Army anesthesiologist = regional anesthesiologist)
Development and integration of RA into Army hospitals (more complex surgery on an outpatient basis) and into combat support hospitals
Improved postoperative pain management
Improved patient/soldier satisfaction
Reduced patient hospital stays and cost reduction
Improved resident research opportunities
Facilitated rehabilitation

Table 3. National Capital Consortium Anesthesiology Residency Peripheral Nerve Blocks for Surgery

Academic Year	Total Residents in Program	Number of Peripheral Nerve Blocks for Surgery Performed by Residents			Total Blocks
		CA1	CA2	CA3	
1999-2000	27	104	64	39	207
2000-2001*	37	242	194	520	956
2001-2002	33	134	217	857	1,208
2002-present† (through 4/03)	39	321	126	967	1,414

Abbreviation: CA, clinical anesthesia year.
*Start of the Army Regional Anesthesia Initiative.
†Establishment of the Regional Anesthesia Section at Walter Reed Army Medical Center.

OAR Mission Description

In November 2002, the authors (CB, EL, CS, JS) deployed from WRAMC, Washington, DC, to Diébougou, Burkina Faso. Burkina Faso (formerly Upper Volta) is a landlocked savanna located in western Africa that gained independence from France in 1960. The population of 12.6 million is one of the poorest in the world, with 45% of the population living below the poverty line (2001 estimate) and approximately 90% of the population engaged in subsistence agriculture in an environment subject of frequent droughts and desertification.[10]

Premission Preparation

The medical mission to Burkina Faso was sponsored and coordinated by The Greater Washington Society of Anesthesiology (GWSA) under the direction of John B. Sampson, M.D., president. The GWSA is a nonprofit organization dedicated to educational programs showcasing physicians who provide health care needs to underserved areas of the world. Cooperation between Army medical personnel and civilian health organizations like the GWSA has advantages for both groups. The GWSA is provided access to skilled medical personnel with experience and desire to operate in austere environments at no cost to the organization. The Army is provided unique opportunities to train medical officers, exercise military medical equipment, and validate casualty care concepts while avoiding many of the political issues and security risks associated with United States soldiers operating in a foreign country. The Army's relationship with civilian organizations, like the GWSA, has the added benefit of teaching medical officers about the political and material logistics of operating in a foreign country from these experienced organizations.

Table 4. Operational Anesthesia Rotation (OAR) Program Goals

Preparation for working and living among patients and families with diverse cultural backgrounds while providing their health care
Preparation for deployment to areas of high prevalence of endemic infectious diseases to include: medical threat estimation, medical intelligence information collection, medical operational plans development, and individual travel medicine consultation
Public health aspects of humanitarian missions such as relevant infectious diseases and risk/benefit issues of prophylaxis options
Understanding basic food and water sanitation
Effects of extreme environmental conditions on patients, staff, anesthetic equipment and medications
Universal precautions in austere environments
Medical supply logistics with travel to and operations in harsh environments
Fatigue and stress management
Triage and medical resource allocation
Spontaneous ventilation: its use in the field to avoid the need for ventilators, increase safety, and extend capabilities, its limitations in complex surgical procedures
Total IV anesthesia: its use in austere conditions and the risks/benefits of this anesthetic
Regional anesthesia: the appropriate use of RA to extend capabilities in a mass casualty situation, improve postoperative analgesia with limited patient monitoring, and minimize risk in austere environments

Once Army anesthesia personnel (at least 1 staff anesthesiologist and 1 anesthesiology resident) are identified, planning for the mission begins 3 to 6 months in advance. Appropriate clearances from the host country's military, passport documents, medical screening, and infectious disease prophylaxis are obtained. A series of informal meetings are held to disseminate information on the pending mission and discuss objectives. They provide a forum for team members to meet each other, discuss problems or concerns with preparation, and share knowledge from the experienced volunteers. The meetings also facilitate discussions on team makeup and support. This information is vital for determining appropriate mission equipment because medical supplies and shipping are limited and costly. Determining what is necessary for field anesthesia rather then what is desirable is a valuable military lesson.

For this mission, we were joined by medical professionals representing Pro-Health International Medical Ministries from Jos, Nigeria, who supplied many of the medical consumables (intravenous

fluid, tubing, needles, and so on). Burkinabe medical officials provided operating rooms in Diébougou and supplied medical oxygen in cylinders. Most of the consumable anesthetic supplies were donated by medical suppliers (expired spinal/epidural trays, medication donations) or purchased through the GWSA. A variety of "field" anesthetic equipment was donated for the trip by manufacturers interested in showing the effectiveness of their devices in difficult conditions. The military anesthesiologist quickly learns strengths and weaknesses of equipment in this challenging environment. In the author's opinion (CB), no anesthesia equipment should be accepted into the Army inventory until it passes muster with actual use on a number of these medical missions.

Mission Execution

Our mission team consisted of surgeons (general, orthopedic, obstetric), medical physicians, health educators, operating room personnel, recovery room personnel, and Army anesthesia physicians. The American members traveled through Paris to the capital of Burkina Faso, Ouagadougou, where we met our Nigerian team members. The team spent a few days in the city for a medical and cultural exchange with Burkinabe medical and government officials. This is a necessary and important part of any mission that should be aggressively attended and never avoided. Interaction with host country officials can lay the foundation for mission (and future missions) success as well as establish liaisons should problems arise. The American Embassy of the host country should also be informed of the mission and a visit to the embassy arranged if possible.

We arrived at the remote village of Diébougou and moved into a Catholic mission retreat that had been donated as our home during the mission. The morning of the first mission day was spent setting up and cleaning the operating room facility. We reserved the smaller of 2 operating rooms for GA using a ventilator and draw-over vaporizer. The larger operating room could support 2 simultaneous operations and was reserved for sedation and RA cases. We established an RA block area in another room. The use of a dedicated block room outside of the operating room greatly improved efficiency because anesthesia could be established before the finish of the previous case. The area also served as our initial processing room to perform preoperative evaluations, establish intravenous access, and perform triage. Our patient monitoring capabilities were limited to 2 portable monitors that were used in the 2 operating rooms. Monitoring for block procedures was accomplished with a Nonin Onyx 9500 pulse oximeter (Nonin Medical Inc., Minneapolis, MN). This highly compact device proved extremely useful and versatile for checking patient pulse rates and oxygen saturation throughout the perioperative period. Nerve blocks were placed using a stimulator and insulated needles (B. Braun Medical Inc., Bethlehem, PA).

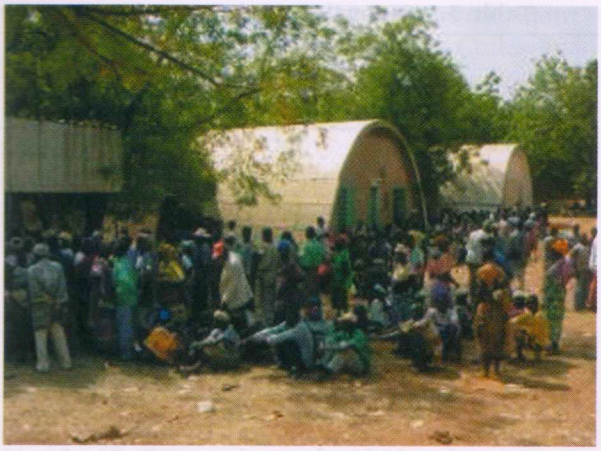

Fig 1. A Burkinabe crowd waiting for medical care.

Burkina Faso embassy officials in Washington DC initially expressed concern about choosing Diébougou because of its remote location. They feared the number of patients in the area would be small and the team would spend considerable amounts of time idle. These fears were unfounded with the team evaluating over 3,000 patients during the 2-week mission, many trucked in from distant areas all around Diébougou. The need for medical services can often be underestimated in developing countries (Fig 1).

A typical operating day began early (0600) with a team meeting over breakfast to discuss issues or upcoming surgeries. The team was then bussed to the mission site, and preparations for the day's procedures began with the surgeons providing lists of cases they had evaluated in clinic and planned to accomplish. The anesthesia team then performed triage from the list attempting to safely serve the greatest number of patients with the resources available. This was tremendously instructive for the staff and resident military anesthesiologist. With only 1 room equipped with a ventilator and vaporizer for GA and the difficulty with performing and recovering patients receiving GA in this setting, there was strong motivation to perform RA whenever possible. The anesthesiology resident (EL) described his frustrations:

"Until I participated in the Anesthesia in Austere Environments course trip to Burkina Faso, Africa, I

Table 5. Mission Surgical Procedures and Anesthetics

Surgical Procedures	Anesthetic	Number of Patients
Cystectomy (cystocele)	General anesthesia	1
Keloidectomy (massive)		1
Laporotomy		1
Oophorectomy (tumor)		1
Submandibular cystectomy		1
Thyroidectomy		1
Unspecified*		2
Hydrocoelectomy	Local anesthetic infiltration	45†
Lipectomy		
Bartholinectomy	Spinal	1
Cesarean section		1
Exam under anesthesia and biopsy		1
Hydrocoelectomy		9
Herniorrhaphy		30
Vaginal hysterectomy		3
Myomectomy	Epidural	2
Vaginal hysterectomy		2
Breast mass excision	Paravertebral block	2
Bilateral scapular cystectomy		1
Osteochondroma excision		1
Umbilical hernia		1
Débridement arm	Brachial plexus blocks	2
Ganglion cyst excision		1
Lipectomy		1
Amputation leg	Lumbar and/or sacral plexus blocks	1
Débridement leg		2
Lipectomy		2
Unspecified*		2

*Specifics on surgical procedure are unavailable.
†Numbers for specific procedures are unavailable.

did not realize how unprepared I was for such a mission. The field anesthesia we practiced there was unlike any training I had experienced. I must have seemed like a brand new intern when be began to operate. *'What do you mean there's no ventilator?' 'You want me to take care of two patients at once in the same operating room?' 'What?' 'You only have one set of monitors for both patients?' 'A manual blood pressure cuff?' 'Aren't the operating rooms air-conditioned?' 'But I want. . .' 'But I need. . .'* It was a long few weeks for me. By the end of the trip I had learned more about being an Army anesthesiologist than I had through all of my residency training. When it's my turn to deploy, I will be ready."

Of the 118 operative procedures performed by the team, only 8 involved GA (mostly major abdominal or head and neck operations). A variety of blocks of the upper and lower extremity, neuraxial blocks, and paravertebral blocks were used for the remaining patients (Table 5). There were no major complications related to anesthesia during the mission. Paravertebral blocks for procedures on the chest and abdomen were particularly useful. One male patient presented with a large bony mass on his right scapula that was removed under thoracic (T2-8 with 5 mL 0.5 % ropivacaine with epinephrine 1:400,000 at each level) paravertebral block with minimal sedation (Fig 2). He remained alert and conversant throughout the procedure and ambulated with assistance to the recovery area after the operation. Unfortunately, the 22-G Tuohy needles we typically use for paravertebral blocks did not arrive with our medical equipment shipment. We adjusted by using 22-G Quincke spinal needles for our paravertebral blocks and opting for neuraxial anesthesia for the large number of hernia operations performed (we typically use paravertebral blocks for many of our hernia operations at WRAMC).

As the mission progressed and resources were consumed, the anesthesia team had to become in-

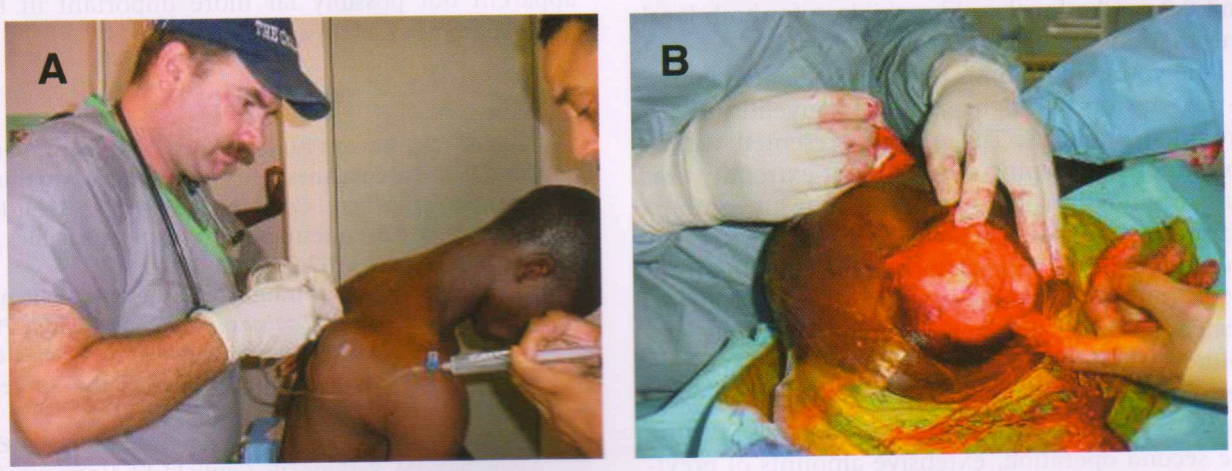

Fig 2. A bony scapular mass being removed using T2-8 paravertebral blocks.

creasingly more innovative with their anesthetic plans. Often technique was based more on available resources rather then preference, a condition likely to be encountered on the battlefield. Continuous peripheral block techniques were desirable in many cases but avoided because of a lack of skilled nursing, pumps, and communications at night. A few patients who underwent obstetric and abdominal operations were managed with lumbar epidural infusions of 0.2% ropivacaine via a Microject infusion pump (Sorenson Medical, West Jordan, UT) when an experienced Burkinabe nurse was available. Despite recent reports of technical difficulties, this pump performed well during our mission.[11]

Another issue was the perception among the group that the potency of our local anesthetics deteriorated over the 2-week period. Because temperature control was unavailable in our facility, medications were routinely subjected to high temperature. This may have adversely affected the local anesthetic. Issues such as this provide valuable research questions that must be answered before RA can be better used on the modern battlefield.

Neuraxial RA was a valuable technique in a variety of cases. Of note on this mission, we had 18 children (6 months-8 years old) who needed inguinal or femoral hernia repair. Because of our limited resources and monitoring capabilities, we performed these procedures under spinal anesthesia (SAB), reserving our limited oxygen for procedures that required GA. The technique has a long history of safe use in the United States but is used infrequently for pediatric patients.[12] The majority of children we treated with SAB experienced a stable, pain- and emesis-free recovery. A variety of medications were used for the SAB depending on availability. Initially, we used 1% tetracaine in 10% dextrose at 0.5 mg/kg. After the supply of tetracaine was exhausted, we extrapolated a dose for bupivacaine and ropivacaine (0.5 mg/kg for the infants and 0.3 mg/kg for the older children for both local anesthetics).[13]

One young man in his twenties presented with a 3-year history of right arm osteomyelitis of his proximal humerus. The patient presented with a continuously weeping and purulent extremity that was resulting in social ostracism from his community. An initial attempt at debridement of the wound under a supraclavicular block (40 mL of 0.5% ropivacaine and epinephrine 1:400,000) revealed an extensive core of necrotic bone surrounded by new bone growth. A second operation performed the next day with GA resulted in profound hypotension from presumed sepsis. During the second operation, extensive amounts of previously unrecognized necrotic bone were discovered. After consultation with the surgeons, we elected to perform a third operation again under supraclavicular block. The patient remained hemodynamically stable throughout the difficult case, and a 5-inch shaft of necrotic bone was removed from the patient providing him his first real chance at recovery (Fig 3).

Fig 3. Debridement of a necrotic humerus under supraclavicular block.

The preceding case examples are just a small sample from a busy and rewarding 2 weeks. The mission surgeons, anesthesiologists, and nurses were all impressed with the utility of PNB in austere environments.

Our mission to Diébougou, Burkina Faso, was the first exposure to Americans (other than missionary workers) that most of the Burkinabes in the area could recall. We were told just before leaving for home that the local mosque and church groups were praying for our safe arrival home and eventual return. The mission's benefits in training military anesthesiologists and improving health care for the Burkinabes are obvious. The benefits of improved understanding between cultures may be less apparent but possibly far more important in the post–September 11th world.

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