Anaesthesia care beyond Operating Rooms:
Newer opportunities & Challenges.

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Technological progress in medical science leads to more interventional procedures, with which we are able to give symptom relief for sicker patients who may not be a candidate for a major surgical procedure. The risk involved in providing anaesthesia for the sicker patients for the interventional procedure is much more than the regular surgery. As a critical care and resuscitation expert and with special skills/knowledge of Anaesthesia, the services of the anaesthesiologists are demanded by non surgical specialists who do not make use of the regular operation rooms for the work.

Providing anaesthesia care in out of operating room situations may be challenging, as changed and variable environments pose unique problems. When providing care at such locations, anesthesiologists must maintain the same high standard of anesthetic care provided in the operating suite. The anaesthetizing location must be surveyed by the anaesthesiologist to determine whether anaesthesia care can be delivered safely in that location before delivery of that care. The requirements for anaesthesia and the patient’s underlying condition do not vary merely because of location, but the conditions under which the anaesthesia care is delivered may vary greatly because of the space and equipment available in these locations. Large, mobile pieces of radiologic equipment, radiation hazards, intense magnetic fields, paramedical personnel not familiar with the anaesthesia team, and other factors may compromise the delivery of quality anaesthesia care.

Despite the availability of detailed guidelines, a recent analysis of closed anaesthesia claims demonstrated greater injury severity and more substandard care than seen with operating room closed claims. Drug interactions were the most common associated factor, followed by drug overdose, inadequate monitoring, inadequate skills for cardiopulmonary resuscitation, inadequate evaluation before sedation and premature discharge from medical supervision were other incidents noted as contributory to the events in outside or procedures. Presence of a dedicated person for monitoring the patient and following the proper guidelines can minimize the events.

Guidelines for anaesthetic care delivered outside the Operating Room American Society of Anaesthesiologists (ASA) 1994 Guidelines for Non–Operating Room Anaesthetizing Locations in-clude recommendations for

1. A reliable oxygen source with backup as required.
2. A working suction source with all proper connections & suction catheters.
3. Waste gas scavenging system.
4. Adequate monitoring equipment to meet the standards for basic anaesthesia monitoring and, in addition, a self-inflating hand resuscitator bag/ transport ventilator.
5. Sufficient safe electrical outlets.
6. Adequate illumination of the patient and anaesthesia machine with battery-powered backup.
7. Sufficient space for the anaesthesia care team.
8. An emergency cart with a defibrillator, emergency drugs, and other emergency equipment.
9. A means of reliable two-way communication to request assistance.
10. Compliance of the facility with all applicable safety and building codes.

It is the responsibility of the anaesthesiologist providing care to ensure that the anaesthetizing location in which that care is delivered meets all applicable standards.

Patient population:

Wide range of patients from newborn to geriatric patients, healthy to critically sick patients will be subject to the anaesthesia care outside or procedures. Children, unconscious / uncooperative or anxious patients, elderly or confused patients all require anaesthesia care. The reasons may be needle phobia, claustrophobia, painful procedures or procedures requiring absolute immobile patient, comorbidity requiring constant monitoring and resuscitation during the procedure. When very advanced and costly procedures are being carried out physicians and patients prefer TOTAL CARE especially when the additional expenditure for anaesthesia care is negligible compared to the procedure charges.

Monitoring:

ASA standards for basic anaesthesia monitoring require presence of qualified anesthesia personnel throughout conduct of the course of anesthesia and continuous evaluation of the patient’s oxygenation, ventilation, circulation, and temperature. Provision is made for the absence of
anaesthesia personnel from the immediate vicinity of the patient if required for safety (i.e., in the presence of radiation hazards), provided that adequate patient monitoring is continued despite the physical separation of the anesthesiologist from the patient. Oxygen concentrations of inspired gas should be monitored with the use of a low-concentration alarm, blood oxygenation should be monitored with pulse oximetry, and ventilation should be monitored by observation of the patient. When present, the position of the endotracheal tube must be verified by observation and by detection of end-tidal carbon dioxide. Continuous end-tidal carbon dioxide analysis should be performed. When mechanical ventilation is used, a disconnect alarm with an audible signal must be present. Circulation is monitored by continuous display of the electrocardiogram, as well as by measurement of arterial blood pressure at a minimal interval of 5 minutes, in addition to other assessments such as auscultation, palpation of pulse, invasive blood pressure monitoring, or oximetry. When changes in body temperature are anticipated or suspected, patient temperature should be assessed. There should be no hesitation to use invasive monitoring if the patient condition warrants so in case for or procedure.

GOALS:
The goals of sedation/anaesthesia outside or can be summarized as follows

- Guard the patient’s safety and welfare
- Minimize Physical discomfort and pain
- Control anxiety, minimize psychological trauma and maximize the potential for amnesia
- Control behavior and / or movement to allow safe completion of the procedure
- Return the patient to a state in which safe discharge from medical supervision is possible.

Problems:
Unfamiliar locations and working conditions pose certain problems like

- Related to physical layout of the facility
- Remoteness from available help.
- Difficult or limited access to patients.
- Unfamiliar or outdated anaesthesia equipment.
- Untrained personnel.

General Precautions:

- Proper check up of anaesthesia machine & equipment
- Availability of adequate number of gas cylinders
- Obsolete and poorly functioning equipment should be discarded.
- Proper grounding of electrical equipment
- Availability of adequate persons and materials for the procedure and monitoring

- Facility for post procedure care/ PACU.

Patient Evaluation:

Clinicians should be familiar with the sedation-related aspects of the patient’s medical history.

These include (1) abnormalities of major organ systems, (2) previous adverse effects with sedation and general anesthesia, (3) drug allergies, current medications, and drug interactions, (4) time and nature of oral intake, and (5) history of tobacco, alcohol, or substance abuse.

A focused physical examination including vital signs, auscultation of the heart and lungs, and evaluation of the airway is recommended.

Preprocedural Preparation:

Patients should be informed of and agree to sedation, including its risks, benefits, limitations, and alternatives. Sufficient time should elapse before a procedure to allow gastric emptying in elective patients. Minimum fasting periods of 2 hours (clear liquids), 4 hours (breast milk), and 6 hours (infant formula, nonhuman milk, and light meal), are recommended for healthy patients. If urgent, emergent, or other situations impair gastric emptying, the potential for pulmonary aspiration of gastric contents must be considered in determining the target level of sedation, delay, or intubation.

Medications: Monitored anaesthesia care (MAC), general anaesthesia (GA) or regional anaesthesia may be required. Midazolam, Fentanyl, Propofol, and Ketamine are frequently used drugs. Dexmedetomidine is useful for conscious sedation as well as for facilitating smooth anaesthesia and recovery when GA is needed.

A moderately sedated child who can respond to light touch can protect his or her airway and a deeply sedated child who can respond appropriately only to pain may not be able to control the airway. The important assessment of the child is not response to stimulation but the ability to protect the airway. Different sedative drugs have differing effects on analgesia versus airway obtundation. Propofol is not a profound analgesic but has profound effects on the airway. Conversely, the sedative drug Dexmedetomidine may provide profound sedation with little depression of respiratory function. Ketamine produces intense analgesia and most children maintain a patent airway and adequate respiratory effort.

When Spinal anaesthesia is needed for day care patients, ropivacaine is a better choice due to less motor block and early recovery.

Combinations of Sedative/Analgesic Agents: Combinations of sedative and analgesic agents may be administered as appropriate for the procedure being performed and the condition of the patient. Ideally, each component should be administered individually
to achieve the desired effect (e.g., additional analgesic medication to relieve pain; additional sedative medication to decrease awareness or anxiety). The propensity for combinations of sedative and analgesic agents to cause respiratory depression and airway obstruction emphasizes the need to appropriately reduce the dose of each component as well as the need to continually monitor respiratory function.

Titration of Intravenous Sedative/Analgesic Medications: Intravenous sedative/analgesic drugs should be given in small, incremental doses that are titrated to the desired end points of analgesia and sedation. Sufficient time must elapse between doses to allow the effect of each dose to be assessed before subsequent drug administration. When drugs are administered by nonintravenous routes (e.g., oral, rectal, intramuscular, transmucosal), allowance should be made for the time required for drug absorption before supplementation is considered. Because absorption may be unpredictable, administration of repeat doses of oral medications to supplement sedation/analgesia is not recommended.

Anesthetic Induction Agents Used for Sedation/Analgesia (Propofol, Methohexital, Ketamine): Even if moderate sedation is intended, patients receiving propofol or methohexital by any route should receive care consistent with that required for deep sedation. Accordingly, practitioners administering these drugs should be qualified to rescue patients from any level of sedation, including general anesthesia. Patients receiving ketamine should be cared for in a manner consistent with the level of sedation that is achieved.

**Anxiolytics/Sedatives**

The most commonly used anxiolytics/sedatives in pediatric sedation are chloral hydrate, diazepam, and midazolam. Chloral hydrate is one of the most widely used sedatives in neonates and children younger than 3 years of age. It is widely used as a sedative to facilitate nonpainful diagnostic procedures such as EEG and CT or MRI. It is rapidly and completely absorbed when given orally. Rectal administration is erratically absorbed and therefore not recommended. Onset of sedation is 30 to 60 minutes, and the usual clinical duration is 1 hour. Although it has a long safety record, it can cause respiratory depression due to airway obstruction, and deaths have been associated with its use alone and when combined with other sedating medications.

The benzodiazepines are commonly used in pediatric sedation. They are anxiolytic, amnestic, sedative hypnotics with anticonvulsant activities but no analgesic properties. Their high lipid solubility at physiologic pH accounts for the rapid CNS effects. As opposed to diazepam, midazolam is delivered in a water-soluble form (pH 3.5), which markedly decreases the incidence of pain on injection and thrombophlebitis. However, the resulting decrease in fat solubility markedly delays transport into the CNS (peak EEG effect 4.8 minutes for midazolam versus 1.6 minutes for diazepam). The sedated child usually becomes compliant but does not lose consciousness. Children frequently move, and another agent, such as an opioid, may be necessary if the child must not move to successfully accomplish the procedure. The benzodiazepines have the advantage of antegrade amnesia in a significant number of patients. The markedly prolonged and variable elimination half-life and active metabolite of diazepam (desmethyl-diazepam) make midazolam a superior sedative drug in children, particularly infants. Time to peak effect after intravenous administration of midazolam is 2 to 4 minutes, and duration is 45 to 60 minutes. Midazolam can be given intravenously, intranasally, orally, or rectally. It is the only drug in this class approved for neonates. Benzodiazepines produce mild respiratory depression and upper airway obstruction. Respiratory depression may become severe in compromised children or in children with tonsil hypertrophy. Benzodiazepines must be given after appropriate guidelines. The combination of benzodiazepines and opioids is particularly troubling because they can produce a “super additive effect” on respiratory depression.

Flumazenil is a specific benzodiazepine receptor antagonist and will rapidly reverse the sedative and respiratory effects of benzodiazepines. It is the first specific reversal agent for benzodi-azepines and rapidly reverses CNS-induced unconsciousness, respiratory depression, sedation, amnesia, and psychomotor dysfunction. The recommended dose of flumazenil is 10 μg/kg up to 0.2 mg every minute to a maximum cumulative dose of 1 mg intravenously. Antagonism begins within 1 to 2 minutes and lasts approximately 1 hour. Because resedation after 1 hour may occur, the child must be carefully monitored for at least 2 hours. Repeat flumazenil may be necessary. It should be noted that flumazenil will not antagonize respiratory depression due to opioids. Flumazenil should not be administered for the routine reversal of the sedative effects of benzodiazepines but reserved for reversal of respiratory depression.

**Barbiturates:**

Pentobarbital is the most commonly used intermediate-acting barbiturate for sedation. It has no analgesic effect and produces sedation, hypnosis, and amnesia. It has a long history of use during radiologic procedures. Sedation starts in 3 to 5 minutes and peaks in 10 minutes. Studies have shown a low incidence of respiratory obstruction and transient desaturation as well as hypotension. The barbiturates tend to make children more sensitive to pain and should be combined with analgesics when used during painful procedures. Newer, shorter-acting, faster recovery drugs are quickly replacing pentobarbital.
Opioids:

Opioid analgesics are rarely used alone for diagnostic and therapeutic procedures in children. These potent analgesics are important during painful diagnostic and therapeutic procedures. They bind with four primary opioid receptor types (mu, kappa, delta, and sigma) that are located in the brain, spinal cord, and periphery. Serious effects of opioids include respiratory depression, bradycardia, hypotension, seizures, and opioid-induced glottic/ chest wall rigidity.

Morphine may be considered for painful procedures (> 1 hour) or when the child will also be in pain after the procedure. The duration of action is 3 to 5 hours after intravenous administration. Morphine may be given orally (0.2 to 0.5 mg/kg), intravenously (0.05 to 0.1 mg/kg [maximum 0.3 mg/kg]), or intramuscularly (0.1 to 0.2 mg/kg). Time to peak effect for oral, intravenous, or intramuscular administration is 60 minutes, 3 to 5 minutes, and 10 to 30 minutes, respectively. Its slow onset and prolonged duration have caused it to be replaced by shorter acting opioids when used for sedation and analgesia for procedures.

Fentanyl has replaced morphine as the opioid of choice for analgesia/sedation for procedures in children. Intravenous fentanyl is a potent pure opioid (i.e., 100 times more potent than morphine) with no amnesic properties. Its high lipid solubility allows for onset within 30 seconds and a peak effect at 2 to 3 minutes. It has a brief clinical duration of 20 to 40 minutes when given in small doses owing to its rapid redistribution to skeletal muscle, fat, and other inactive sites. Unlike morphine it has no active metabolites. Fentanyl’s clearance is decreased and its half-life is increased in preterm and term infants. It is fully reversed by opioid antagonists and is frequently used with a short-acting anxiolytic (midazolam). Intravenous doses usually start at 0.5 to 1 μg/kg and are titrated every 5 minutes to effect but not to exceed 5 μg/kg. Doses must be given in small aliquots and carefully titrated to avoid chest wall and glottic rigidity. Close post-procedural observation is required because respiratory depression can outlast analgesia.

Remifentanil is the newest rapid-acting opioid. This rapid onset, extremely potent, lipophilic short-duration opioid is metabolized by plasma cholinesterase. Remifentanil has been used for intraoperative sedation by anesthesiologists and in intubated children in the ICU. Remifentanil is associated with a high incidence of apnea and chest wall rigidity and should not be used by the non-anesthesiologist for pediatric sedation.

Opioid antagonists specifically reverse the respiratory and analgesic effects of opioids and should be readily available when opioids are used. Naloxone is the most commonly used an-agonist. Opioid antagonists should not be used for routine reversal of the sedative effects of opioids but reserved for reversal of respiratory depression / respiratory arrest. Naloxone may be given intravenously, intramuscularly, or subcutaneously. The initial dose for respiratory depression is 0.01 mg/kg titrated to effect every 2 to 3 minutes. Ten to 100 μg/kg up to 2 mg may be required for reversing respiratory arrest. Adverse reactions from reversal of analgesia include nausea, vomiting, tachycardia, hypertension, delirium, and pulmonary edema. Patients on long-term opioid therapy should be given opioid reversal agents in low doses and with extreme caution because withdrawal seizures and delirium may occur. If naloxone is used, then the patient should be observed for a minimum of 2 hours. Repeat naloxone may be necessary. Nalmefene (Revex) has a longer half-life (~ 10 hours) than naloxone. Its half life outlasts the effects of fentanyl and negates the treatment of pain with opioids for several hours.

Systemic Anesthetics

These drugs should be used only by anesthesiologists or other practitioners who have specific training in their use and have advanced airway management skills because airway obstruction, apnea, and cardiovascular instability may quickly and unpredictably occur. Ketamine is one of the few sedatives that produce both amnesia and analgesia. The clinical appearance is that of a patient who has opened eyes (usually with horizontal nystagmus) but does not respond to pain. Ketamine has been shown to preserve cardiovascular function in most cases and to have limited effects on respiratory mechanics and allows for spontaneous respirations. Ketamine is associated with nonpurposeful motion, which limits its usefulness when immobility is necessary (e.g., use during CT). Ketamine can markedly increase cerebral blood flow and is contraindicated in patients with increased intracranial pressure. Other contraindications include those with head injury, open globe injury, hypertension, and psychosis. Ketamine can decrease the response to hypercarbia, as well as cause laryngospasm, coughing, and apnea. No antagonist is available. Typical starting doses are 1 to 2 mg/kg intramuscularly, 0.25 to 1.0 mg/kg intravenously, or 4 to 6 mg/kg orally. The onset after intramuscular injection is 2 to 5 minutes, with a peak of 20 minutes; duration can be 30 to 120 minutes. Onset after intravenous administration occurs in less than 1 minute, with a peak effect in several minutes and duration of action of approximately 15 minutes. Oral doses of 4 to 6 mg/kg are usually combined with atropine and have an effect in 30 minutes and last up to 120 minutes. Larger doses or supplementation with other sedatives or opioids may produce deep sedation/general anesthesia. Ketamine should be administered with an antisialagogue (atropine, 0.02 mg/kg, or glycopyrrolate, 0.01 mg/kg) because copious secretions from ketamine alone may induce laryngospasm. Although initially thought to maintain airway reflexes, this is not always
Nitrous oxide (N2O) is a potent inhalation analgesic with a peak effect in 3 to 5 minutes and very rapid return to baseline when discontinued. A premixed tank of no more than 50% N2O is available (Entonox). Administration of N2O can be used for “minimal sedation”. (1) only ASA-PS I or II patients; (2) only 50% nitrous oxide or less is used; (3) inhalation equipment must have the capacity to deliver 100% oxygen and never less than 25% oxygen; and (4) a calibrated oxygen analyzer must be used. Although N2O in 50% concentration with oxygen usually produces “minimal” sedation, the addition of any sedatives/hypnotics may rapidly produce a deeper level of sedation and require increased monitoring and vigilance.

Dexmedetomidine is an imidazole 02 agonist that is similar to clonidine but with an even higher 02 : 01 specificity ratio of 1600 : 1. Its elimination half-life in children is 2 hours. The drug is highly lipid soluble and quickly crosses the blood-brain barrier. Its CNS effect is to stimulate receptors in the medullovasomotor center, which decreases sympathetic tone. It also stimulates central parasympathetic outflow and decreases sympathetic outflow from the locus ceruleus of the brainstem. The decreased outflow from the locus ceruleus allows for increased activity of the inhibitory GABA neurons, which cause sedation and analgesia. Dexmedetomidine is approved for sedation of ventilated adult patients in the ICU but not in children. When administered in clinical doses it causes limited effects on ventilation in adults and may mimic natural rapid-eye-movement sleep. The initial dose must be given over 10 minutes, followed by an infusion. When given in the recommended fashion it decreases blood pressure and heart rate in adults. It should be used with caution in children with preexisting bradycardia, atrioventricular conduction defects, hypotension, and decreased cardiac output. Dexmedetomidine may provide safe sedation for procedures with minimal effect of the airway and therefore markedly improve safety.

Patient transport to Recovery Room/post anesthesia care unit:

The patient must be medically stable before transport. The patient must be accompanied to the recovery area by the individual providing the anesthesia or sedation/analgesia care, and monitoring used according to the patient’s medical condition must be maintained. Provision of oxygen delivery and monitoring while the patient is on the transport cart may be required. Appropriate recovery facilities and staff must be provided. In the recovery area, the patient’s condition must be documented and continually assessed. Immediate availability of personnel trained in advanced cardiac life support should be ensured. Patients should not be discharged until they have met specific discharge criteria. Clear directions are to be given in writing and explained to the care taker at the time of discharge.
1. Anaesthesia for diagnostic neuroradiological procedures:
   - Computed Tomography (CT)
   - Magnetic Resonance Imaging (MRI)
   - Pneumoencephalography
   - Angiography: Includes mainly spinal cord and cerebral angiography

Patients in the radiology suite may have severe underlying medical conditions such as cardio-vascular, pulmonary, or neurologic disease. Indeed, they may be in the radiology suite, as opposed to the operating suite, precisely because their severe underlying disease precludes operative intervention. Finally, anesthesiologists may be summoned relatively late in the care, after failure of sedation/analgesia administered by the radiologist or nonanaesthesia personnel. Clearly, this situation is undesirable, and open communication between the departments of radiology and anesthesiology is essential. Special precautions should be taken in MRI due to the effect of magnetic field on ferrous objects.

2. Anaesthesia for interventional radiology.

Angiograms, angioplasty and angio-embolization are becoming a regular work in many radiology labs. Most of the procedures can be done as a Monitored Anaesthesia Care and moderate sedation / Conscious Sedation, but some require complete immobilization and require General Anaesthesia with controlled ventilation. Radio Frequency Ablation of the solid tumour mass in the lungs, Liver and bones is another area where similarly anaesthesia service could be utilized. Some of the RFA patients will benefit from continuous regional block with catheter for post procedural pain relief. The iodinated contrast media used in the radiology and neuroradiology suites, as well as the cardiac catheterization laboratory, may cause significant adverse reactions, and patients receiving contrast media require close monitoring.

3. Anaesthesia for radiotherapy

Intra Operative Radiation Therapy (IORT) & external beam radiation; MAC or moderate to deep sedation may be needed for anxious patients to keep without moving during the CT simulation and External RT especially in paediatric patients who may require 5/7 days sedation/TIVA that too for a month or so depends upon the number of fractions needed. Peripherally inserted CV Access will be useful in these patients.

Intra Cavity Radio Therapy (ICRT/ BRACHY-THERAPY): Compared to Low Dose Rate therapy taking nearly 24 hours time the High Dose Rate with Iridium 192 the treatment time is only 20 minutes and the whole process will be over in 3-4 hours time. ICRT will be used in Carcinoma Cervix patients and these patients could be managed as Day Care patients under regional anaesthesia /CS/GA. Subarachnoid Block with ROPIVACAINE and FENTANYL works for the period of complete treatment and avoids involuntary movement of the lower limbs causing displacement of the applicator / implants and if there is any misplacement it allows to correct the applicator after confirming under IMAGE.

4. Coronary angiography and cardiac catheterization,

5. Anaesthesia for electroconvulsive therapy (ECT),

6. Anaesthesia in Emergency Room/ Trauma care Unit,

7. Anaesthesia inEmergency Room/ Trauma care Unit,

8. Anaesthesia for IVF & GIFT: To be aware of the Ovarian Hyper Stimulation Syndrome.


10. Anaesthesia for children in Oncology/ Rheumatology/ Nuclear Medicine etc.

Anaesthesia care in remote locations: These include war fronts and other mass casualties, including disasters and terrorist violence etc. The guiding principles of care are same as envisaged in “minimum monitoring and safety standards”, advocated by the ISA. There is no justification in giving anaesthesia (other than field and local blocks) without ensuring the availability of a reliable oxygen source, facilities to establish definitive airway and pulse oximetry. On the other hand resuscitation for basic and advanced life support and comprehensive trauma life support (CTLS) should be undertaken whenever and wherever necessary and feasible. The techniques and extent of the life support instituted will depend upon the place, available facilities and resuscitator’s expertise.

Conclusion: The role of anaesthesia outside the operating rooms is rapidly expanding and evolving along with the advances in interventional radiology and other invasive modalities. However, we must understand that there are many constraints, as the co-morbid conditions of the patients are similar and often more severe than what we face in the operating rooms, and in increasingly complex diagnostic and therapeutic procedures are being performed on sicker patients. Understanding the anaesthetic constraints and complexities and keeping abreast with the current developments are crucial in ensuring the maximal benefits to and safety of the patients.

Suggested reading:

Miller’s Anesthesia Seventh edition: Ronald D Miller et al, Chapter 79 – Anaesthesia at Remote Locations, Paul E. Stensrud