REVIEW ARTICLE

Sedation Management on ECMO

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Abstract

Sedation, analgesia, and muscle relaxants are an integral part of critical care unit, which works like a double-edge sword, and hence judicious use of each agent remains the matter of primary concern. These get more compounded, especially when the patient is on extracorporeal therapy. The patient who needs extracorporeal therapies besides being critically ill also has altered pharmacokinetics for varied reasons and usually has longer ICU stay. Recently, there is a paradigm shift in practice of sedation in critical care unit from deep and prolonged sedation to short and minimal sedation. The basic goal of sedation therapy in a critical care unit is to keep the patient comfortable with minimal possible sedation, avoid muscle relaxants as far as possible, and try to give sedation break.

The commonly used drugs are opioids, benzodiazepines, major tranquilizers, and anesthetic agents like barbiturates, propofol, etc. Ideal sedative agents during ECLS should be short-acting as daily sedation break is mandatory to assess CNS status, should not be reacting to the circuit (like fentanyl and propofol), and cardiostable.

Extracorporeal circuits alter the pharmacokinetics of sedative agents by increase in the volume of distribution, circuit adsorption, and hypoproteinemia secondary to systemic inflammatory response syndrome (SIRS).

The need for sedation in cardiac ECMO is very limited, provided there is no associated lung pathology (like pulmonary edema). Cardiac patient can well be kept off the ventilator, or if already intubated, can be extubated at the earliest so that the sedation requirement is minimized.

In respiratory ECMO, invariable sedation is required, especially in the first few days till the time the patient stabilizes. Sedation requirement after 48 hours of ECMO is mostly because of patient-ventilator asynchrony and the air hunger. This can be to some extent managed by maintaining low PCO_2 (less than 30), which can be achieved by keeping high-sweep gas.

The different scoring systems that can be followed are modified motor activity assessment scale (MMAAS) and Richmond agitation-sedation scale and comfort score. The monitoring scale is as per the institutional protocol.

In contrast to the sedated patient, the awake patient has multiple advantages on medical, psychological, and social front.

Keywords: Awake ECMO, Pharmacokinetics in ECMO, Sedation during ECMO.

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Introduction

Sedation, analgesia, and muscle relaxants are an integral part of critical care unit, which works like a double-edge sword. These get more compounded, especially when the patient is on extracorporeal therapy. The patient who needs extracorporeal therapies, besides being critically ill, also has altered pharmacokinetics for a varied reason and usually has longer ICU stay. Recently, there is a paradigm shift in the practice of sedation in critical care unit from deep and prolonged sedation to short and minimal sedation. Sedation practices vary with different critical care units. However, the basic principle of minimizing the use of sedation with safety in mind remains universal. Each unit follows some kind of assessment tools and has its own sedation protocols for when, which, and how to use sedation.[1–3]

Now, it has been established beyond doubt that use of sedation is associated with both short-term and long-term adverse effects, but at the same time, it is an essential tool in critical care units. The reason we need sedation is to give comfort and pain relief to the patient to relieve anxiety and delirium. It induces amnesia so that the patient does not have psychological effect from the event. It decreases the metabolic rate and thereby decreases oxygen consumption and cardiac output. In noncooperative and agitated patient, it decreases the risk of catheter malposition and decannulation. It helps to improve patient ventilatory asynchrony and thereby oxygenation.

The immediate adverse effect of use of sedation and muscle relaxant is hemodynamic instability and loss of spontaneous drive, which leads to atelectasis and delays lung recovery leading to prolonged ventilation. [3,4] Also, that makes the patient more prone for ventilator-associated lung injuries especially pneumonia.[5,6] The prolonged use of sedation and especially muscle relaxants is associated with critical care myopathy, which ultimately increases the ventilatory days and ICU stay days. Deep sedation also makes the neurological assessment difficult.

Decreased sedation and spontaneous breathing will increase lymphatic drainage and are associated with reduced length of stay and reduced mechanical ventilation.[7–9] Early mobilization of the patient on ECMO gives comfort to the patient, it counteracts muscle atrophy, and reduces the risk of bed sores, venous thrombosis, and

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Table 1: Goal of sedation

- Keep the patient comfortable with minimal sedation.
- Daily interruption – give awake cycle.
- Minimal adverse events related to sedation.
- Avoid muscle relaxant as far as possible.

Table 2: Indication for sedation

Indications for sedation
- To relieve pain and anxiety
- To improvise gas exchange
- In a restless and agitated patient to prevent patients from removing lines
- For patient-ventilator asynchrony
- To give a normal sleep pattern in night
- Before any procedure, cannulation, and decannulation

Indications for muscle relaxants
- Patient-ventilator asynchrony
- When patient movement interferes with venous return
- In the rare situation when excessive patient movement threatens accidental decannulation

ICU-acquired myoneuropathy.[7,10] While withdrawing sedation, psychotic stage is usually seen as a withdrawal phenomenon that can be treated with antipsychotics or with half the dose of muscle relaxants. Usually within 2 days, the patient wakes up normally and then we can stop muscle relaxant.

Indications of Sedation

Sedation and muscle relaxants should be used judiciously. One should have a clear idea about why and when the sedation should be used. The basic goal of sedation therapy (Table 1) in a critical care unit is to keep the patient comfortable with minimal possible sedation, avoid muscle relaxants as far as possible, and try to give sedation break.

Minimum sedation and daily interruption help us to assess patients neurologically, which will help us to diagnose neurological complications at the earliest. It has been found to have shortened the length of mechanical ventilation and also has reduced the complication [8,11] like ventilator-associated pneumonia (VAP). This strategy of sedation break helps the patient to be aware about the surrounding and also some interaction with the staff and relatives. This also helps at the social front to keep relatives motivated and satisfied. Lighter sedation is associated with less drug accumulation that may reduce ICU length of stay, duration of ventilation, reduced ventilator-induced diaphragmatic dysfunction, and risk of delirium, which is associated with risk of mortality. [9,12]

Sedation should be used with specific indications (Table 2). Sedation should be used to relieve pain and anxiety. It is used to calm down the violent patient and to prevent those removing lines. It should be given to maintain the normal sleep pattern in the night so that they wake fresh in the morning and they are oriented to time. In case when there is patient-ventilator asynchrony, sedation is indicated after ruling out all other causes of asynchrony. In severe cases of respiratory failure, when the patient requires a high ventilator and ECMO support to maintain saturations, sedation should be used to decrease the metabolic activity and thereby decrease the oxygen (O_2) consumption and carbon dioxide (CO_2) production. As mentioned earlier, muscle relaxants should be avoided as far as possible and should be given only when sedation fails to relax the patient completely and he still shows patient-ventilator asynchrony. During ECMO, at times, we require to use muscle relaxants to avoid any kind of movements as the movement interferes with venous return (thereby ECMO flow) or it leads to excessive recirculation in VV ECMO. It should be used in the rare situation when excessive patient movement threatens accidental decannulation.

Table 3: Range of drugs available

Sedatives	*Analgesics*	*Hypnotics and others*
Benzodiazepines	Morphine	Quetiapine
Clonidine	Fentanyl	Risperidone
Dexmedetomidine	Meperidine	Olanzapine
Propofol	Remifentanil	Haloperidol
Thiopentone	Oxycodone	Fluoxetine
Ketamine		Inhalational
Etomidate		
Chloral hydrate		

Pharmacological Agents

Various sedatives and muscle relaxants are used in critical care. The commonly used drugs are opioids, benzodiazepines, major tranquilizers, and anesthetic agents like barbiturates, propofol, etc. Ideal sedative agents during ECLS should be short-acting as daily sedation break is mandatory to assess CNS status. It should not be reacting to circuits like fentanyl and propofol. It should be cardio stable (Table 3).

Opioids are usually the preferred agents in critical care units for analgesia and sedation. The agents that are available are morphine, buprenorphine, fentanyl, and remifentanil. The problems with opioid derivatives are they can cause respiratory depression, hypotension, gastric hypomotility, and constipation. Rarely, they can cause hallucinations and agitation.

Benzodiazepines are the drug of choice for sedation but do not have any of analgesic effects. Usually, they are used in combination with some analgesics. The agent that is commonly used in the critical care unit is midazolam. Barbiturate pentobarbital has not much been used in critical care units. Propofol has been used in the critical care unit, but the problem is the lipid base and can cause hypotension. It requires a separate line as it is lipid-based and also the chances of infection increase. During the ECMO run, it is not used as it gets adsorbed to the membrane and can decrease the membrane function. However, it is more known with silicon oxygenator than hollow fiber or polymethyl pentene (PMP) oxygenator. So, some centers still use propofol even during ECMO run (Table 4).

Ketamine due to its sympathomimetic property and dexmedetomidine due to its awake analgesia are getting popularity in the critical care unit. Ketamine is safe to be used in hypotensive patients, and also it relieves severe bronchospasm, hence it is a drug of choice for sedation in status asthmaticus. The problem with ketamine is hallucination and nightmares, and also it increases secretion. Usually, it is used in combination with midazolam. Dexmedetomidine is relatively safe, short-acting, and does not cause respiratory depression. It has a better analgesic effect. It is popular for awake analgesia, but usually not preferred to be used for more than 48 hours. The details of the few commonly used agents are given in Table 4.

The pharmacokinetics of these various agents has some variation in critically ill patients due to altered metabolism. This is more exaggerated when the patient is on extracorporeal therapy.

Table 4: Dosage of commonly used sedative agents in ICU

Name	*Dosage*	*Features*
Fentanyl	Bolus – 0.1–0.3 µg/kg Infusion – 0.1 µg/kg/hour	Synthetic opioid, 50–100 times more potent for pain relief compared with morphine. It is the shortest and quickest-acting analgesic.
Remifentanil	Infusion – 0.6–15 µg/kg/hour	Even quicker and shorter-acting than Fentanyl
Morphine	Bolus – 5 mg Infusion – 0.07–0.5 mg/kg/hour	Causes respiratory depression, hypotension, and reversal – Naloxone
Buprenorphine	Bolus – 0.1–0.3 mg Infusion – 0.01 mg/kg/hour	Potent synthetic opioid analgesic and anesthetic
Ketamine	Bolus – 0.25–1 mg/kg Infusion – 0.25–1 mg/kg/hour	Remains as a drug of choice for hemodynamically unstable patients. Can cause hallucinations and nightmares, increased secretions
Lorazepam	Bolus – 0.04 mg/kg	Duration of action is 6–10 hours. It is to be used as intermittent bolus
Midazolam	Bolus – 0.1 mg/kg Infusion – 0.5–5 µg/kg/minute	Short-acting benzodiazepine, three times potent than diazepam. Can cause respiratory depression, hypotension, myocardial depression, and antidote – flumazenil
Pentobarbital	2–6 mg/kg/dose IV over 3–5 minutes as intermittent boluses can be given 4–6 hourly	Barbiturates should not be used as a routine drug
Propofol	Bolus – 0.5–1 mg/kg, Infusion – 25–70 µg/kg/hour	Lipid emulsion. It is both intravenous sedative and anesthetic agent. It is a potent sedative – hypnotic drug. Adverse – hypotension and vasodilatation, hypertriglyceridemia, bacterial contamination, and propofol infusion syndrome (myocardial depression, shock, profound metabolic acidosis, rhabdomyolysis, and renal failure)
Dexmedetomidine	Bolus – 1 µg/kg Infusion – 0.2 – 0.7 µg/kg/hour	Selective a_2 receptor agonist. It is safe and as effective as benzodiazepines. Hypotension and bradycardia, easily arousable
Pancuronium	Bolus – 0.1 mg/kg IV Infusion – 0.02 – 0.1 mg/kg/hour	Long-acting neuromuscular blocking agent
Vecuronium	Bolus – 0.1 mg/kg IV Infusion – 0.06 – 0.15 mg/kg/hour	Short-acting neuromuscular blocking agent, cardiostable agent excreted mainly by the liver
Atracurium	Bolus – 0.4 mg/kg IV Infusion – 0.6 – 1.2 mg/kg/hour	Safe to be used in renal and hepatic failure, histamine release, and causes hypotension
Cisatracurium	Bolus – 0.15 mg/kg IV Infusion – 0.06 – 0.24 mg/kg/hour	Curare derivative and is independent of both hepatic and renal metabolism

The patient on ECLS has an altered physiology due to the extracorporeal circuit. This extracorporeal circuit adds into circulating blood volume, which leads to an increase in the volume of distribution and even has dilutional effect. Second, when blood comes in contact with this foreign circuit, it leads to activation of chemical mediators resulting in a cascade of reactions termed as SIRS (Table 5).

Moreover, the patients are critically ill with compromised organ functioning and some of them are in multiorgan failure. All these will alter the pharmacokinetics and pharmacodynamics of the drug in terms of blood level, tissue penetration, and elimination of drugs. Also, when the patient is on ECMO, there is a decrease in plasma protein as it gets adhered to the circuit, so those drugs requiring protein binding will be a problem. Many drugs like propofol and fentanyl get adsorbed in the circuit and they are required in high dose for the desired effect to come. In VA ECMO, as there is a nonpulsatile flow, the cerebral circulation is altered and even the blood–brain barrier function is also altered that might exaggerate the effect of sedative dose.

There are few *in vitro* and *in vivo* studies done regarding the sequestration of various sedative agents in ECMO circuits and pharmacokinetics of various agents while on ECMO. The few studies have been given in Table 6. The final conclusions derived from the different studies for commonly used sedative agent are given in Table 7. Drug sequestration in ECMO circuits also depends on the circuit used[10,13] and the surface area of the circuit. Sequestration is found more in silicon oxygenator and less in hollow fiber oxygenator (Fig. 1), drug sequestration in Quadrox oxygenator (see Fig. 2). Again, it will also depend on whether the circuit is coated or uncoated circuit. Patients on ECMO often have increased sedation requirements.[11,14]

Table 5: Factors affecting sedation during ECMO

Circuit-related factors	*Patient-related factors*
• Increased volume of distribution	• Changes in serum protein concentrations and protein binding
• Sequestration of sedative drugs[13,14]	• Altered hepatic, renal, and cerebral blood flow leading to impaired elimination
• Age of the circuit	• Organ dysfunction

Sedation Strategy in ECLS

Sedation strategy will differ as per the institutional policy and every institute needs to modify their sedation policy for the patient on

Table 6: Case studies on sedation and ECMO

Study	*Investigators*	*Outcome*
Sequestration of drug in the circuit may lead to therapeutic failure during extracorporeal membrane oxygenation	Shekar et al., Critical Care, 2012	Significant drug loss after 24 hours in Jostra Rotaflow / Quadrox D
Population pharmacokinetics of intravenous clonidine for sedation during pediatric ECMO and CVVH	Niina Kleiber et al., British Journal of Clinical Pharmacology, 2017	Increased CL and Vd need higher dose on ECMO
Phenobarbital dosing and pharmacokinetics in a neonate receiving extracorporeal membrane oxygenation	Elliott and ML Buck	Neonates on ECMO require larger phenobarbital doses to achieve desired serum concentrations due to the presence of large exogenous blood volumes for priming, as well as loss of drug during circuit changes, extraction by the circuit, or hemofiltration.
In vitro study sedative clearance during extracorporeal membrane oxygenation	Varsha Bhatt - Mehta, Gail Annich et al.	Up to 50% of a dose of lorazepam and 40% of a dose of morphine may be extracted by PVC and MO during bypass, depending on the age of the circuit. As the circuits become older, this amount could increase.
In vitro evaluation of sedative drug losses during extracorporeal membrane oxygenation	Mulla, Lawson et al., 2000	Results revealed significant uptake of drugs with losses in the range 40–98% and in the order propofol • diazepam • midazolam • lorazepam. When albumin was used, additional 10% increase in uptake
In vitro adsorption of analgosedative drugs in new Extracorporeal membrane oxygenation circuits	Raffaeli et al., PCCM Journal, 2018	Significant loss of lipophilic drugs (at 24 hours), different adsorption of midazolam, and adsorption varies with different ECMO circuits

Table 7: Sedative agents during ECLS

Sedative agents	*Study conclusion*
Propofol	High sequestration in ECMO circuit hence are not the ideal agents to be used. If used, there blood level will not be achieved till the circuits get fully saturated, so it requires initially high dose to saturate the circuit. Also, whenever the circuit is being changed, the same thing will follow.
Fentanyl	*In vitro* studies show 70% irreversibly bound to the circuit. Tenfold higher dosing in a case series. Almost 97% drug loss after 24 hours in Maquet system.[11,14]
Morphine	Data are conflicting, but show high interpatient variability in clearance, increasing fivefold after 10 days in one case series. Clearance appears to increase after decannulation that could precipitate withdrawal. Binding may increase to 40% as the circuit ages. Minimal drug loss after 24 hours in Maquet circuit.[11,14]
Opiates and benzodiazepine	Gets adsorbed in the circuit but to a lesser degree so they are the drug of choice for sedation. Probably they are to be used in higher dosage, but the exact dosage is not recommended due to paucity of studies and recommendation is to use the dosage as per clinical response.
Lorazepam	Data are limited to *in vitro* studies. Sedation requirements appear to increase over time due to either adsorption in the circuit or tolerance.
Phenobarbital	Case reports show increased requirements particularly after circuit change. *In vitro* data are conflicting, which ranges from no effect to 17% of drug lost to the circuit.
Midazolam	Significant drug loss after 24 hours on extracorporeal membrane oxygenation.

ECLS. Again, the sedation policy for the ECLS will be different for cannulation, for ECLS run, and for decannulation.

Sedation in ECMO is required for cannulation and decannulation. Sedation policy during cannulation can be the same as the routine critical care policy. The sedation policy during cannulation will depend on the condition of the patient at the time of cannulation, e.g., cannulation while resuscitating (for ECPR) does not require sedation. Propofol can be used for cannulation but not for ECMO run. The patient should be given a full anesthetic dose of sedation during cannulation to alleviate the pain and anxiety. Even muscle relaxants should be used to prevent the movement and possible chances of air embolism, especially while cannulating the jugular vein. Decannulation should be done under local anesthesia with mild bolus dose of sedation like fentanyl or benzodiazepine. Muscle relaxants are usually avoided post decannulation, especially in prolonged VV ECMO as that will decrease the spontaneous drive which is essential for carbon dioxide elimination. Post decannulation, the sedation policy remains like a routine critical care policy.

During the ECMO run, the sedation requirement is not mandatory, it depends on various factors like the mode of ECMO, the patient's condition, flow requirements, etc. Also, the strategy for sedation during the ECMO run definitely requires modification and is as per compatibility with the ECMO circuit. The basic plan is to use minimum sedation as far as possible. A policy and tradition of minimal sedation has evolved at the Karolinska Institute, Sweden. Initially for few days, the patient is sedated with the infusion

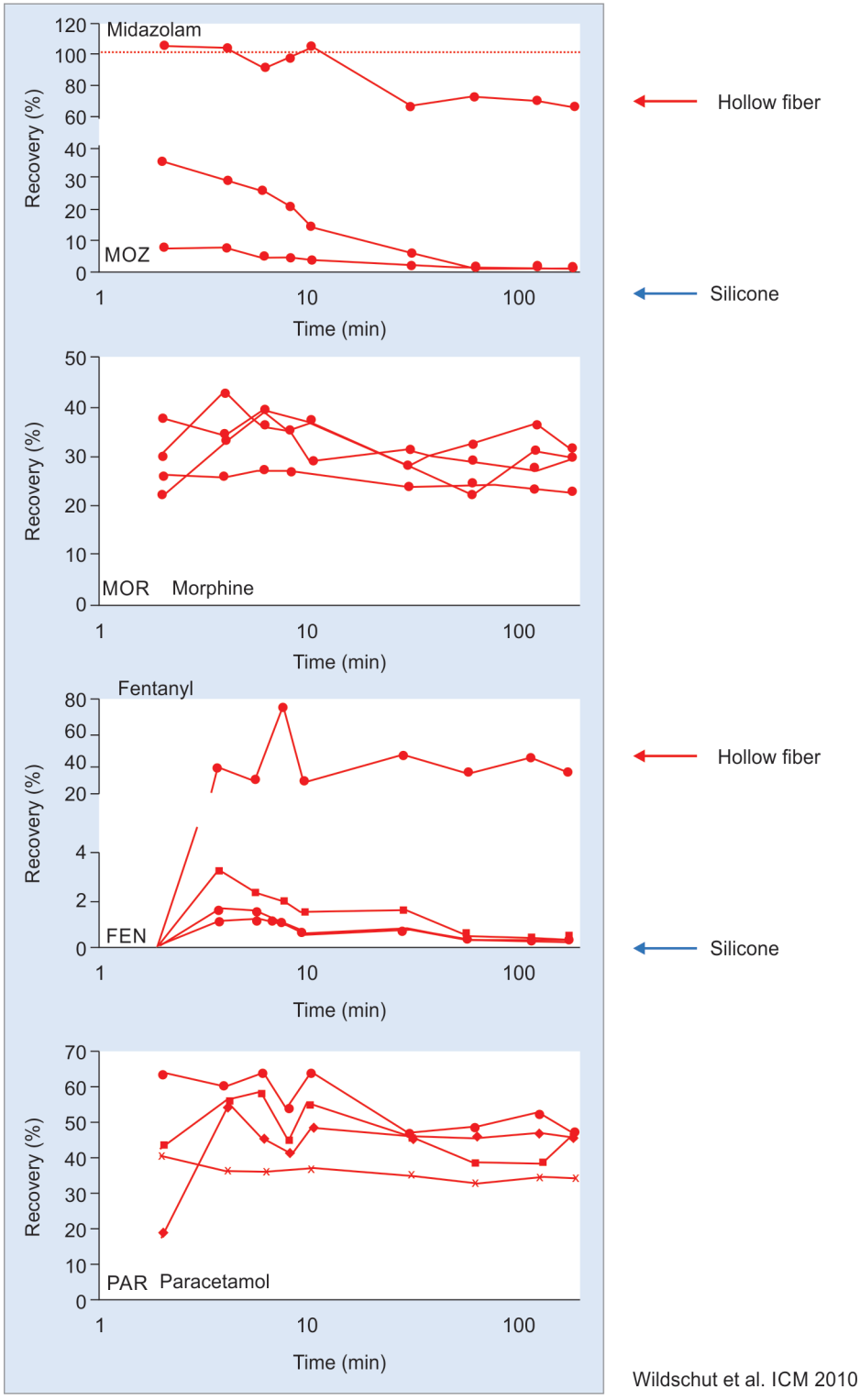
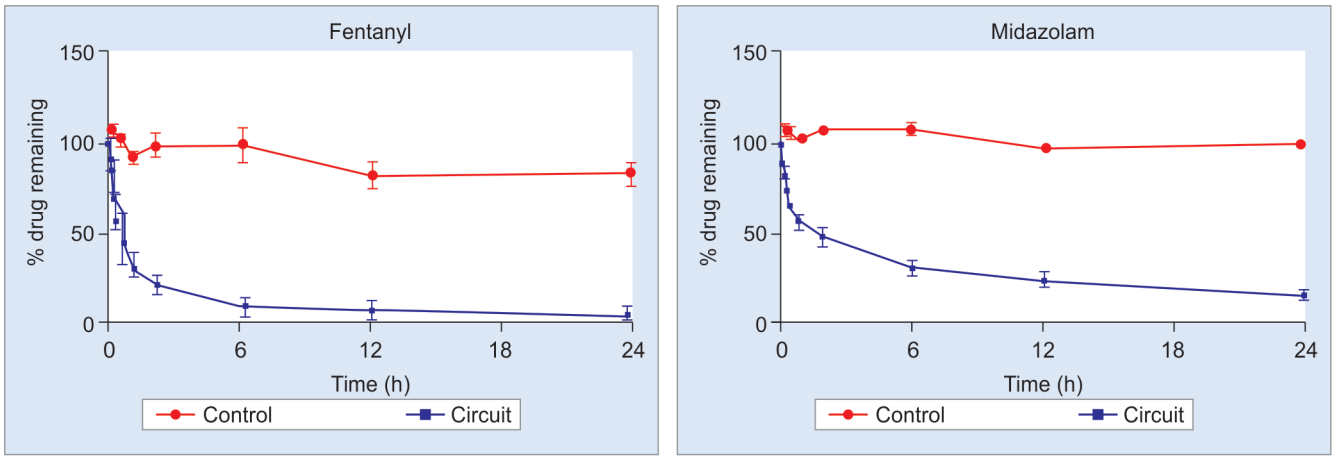


Fig. 1: Drug sequestration with different oxygenator

of opiates or benzodiazepine with daily interruption. Sedation should be stopped as soon as the patient stops fighting and gets acquainted.

The need for sedation in cardiac ECMO is very limited, provided there is no associated lung pathology (like pulmonary edema). Cardiac patient can well be kept off the ventilator or, if already intubated, can be extubated at the earliest, so that the sedation requirement is minimized.

In respiratory ECMO, invariable sedation is required, especially in the first few days till the time the patient stabilizes. Sedation



Drug loss after 24 hr in Jostra rotaflow/quadrox D ECMO

Fentanyl	97%
Morphine	0%
Midazolam	90%
Meropenem	80%
Vancomycin	10%

Fig. 2: Drug sequestration in ECMO circuit

requirement after 48 hours of ECMO is mostly because of patient-ventilator asynchrony and air hunger. This can be to some extent managed by maintaining low PCO_2 (less than 30), which can be achieved by keeping high-sweep gas and maintaining pH around 7.45. Another reason is patient's anxiety, pain, and agitation. The other treatable causes like mucus plug or excess secretion in the endotracheal tube and hypoxia, should be ruled out and, if present, should be addressed immediately.

In long-term respiratory ECMO and ECMO in chronic lung diseases, the sedation requirement is not very high. In these cases, one should try for awake ECMO, and only mild sedation should be used, especially during the night, to facilitate sleeping. Analgesics to be given always prior to minor procedures such as line or chest drain placement or other patient care. For the patient who has received long-term opiates, clonidine can be used to facilitate weaning off opiates. As mentioned earlier about the drug adsorption to the circuit, whenever there is a change of circuit, we might require some bolus dose of sedation.

Manytimes in prolonged respiratory ECMO, sedation may be required for a long time, and some patients do develop tachyphylaxis. They even do not get sedated with high doses of sedative agents, and you might require to use other sedative agents. So, in such cases, alternate groups of sedative agents are used for few days to break this cycle of habituation and drug tolerance.

It is essential to have daily team discussions about the phase of the disease, targeted sedation as per phase of the disease, arousal assessment, sedation weaning plan, and daily extubation readiness testing.

ELSO Guidelines

The patient should be thoroughly sedated to the point of light anesthesia during cannulation and management for the first 12–24 hours.[12,15]

After 24–48 hours: moderate-to-minimal sedation.

After 48 hours: minimal to no sedation.[13,16]

For adult patients, the RASS score is a good way to manage sedation.

Table 8: Modified Ramsay Score

0 – Unresponsive
1 – Responsive to noxious stimuli
2 – Responsive to touch or name
3 – Calm and cooperative
4 – Restless and cooperative
5 – Agitated
6 – Dangerously agitated and uncooperative

Conversion to tracheostomy should be considered early in the course in patients over 5 years of age to allow decreasing sedation.

Holding sedation and analgesia long enough to do a neurologic exam should be done daily (a daily drug holiday).

Monitoring of Patient

Analgosedative dosing should be guided by clinical monitoring and validated sedation and pain scales. A clinical sedation score is to be obtained every 4 hours and sedation is to be titrated accordingly. The different scoring systems that can be followed to guide overall sedation practice are the Modified Ramsay Score (Table 8) or RASS[1–3] (Table 9). The monitoring scale is as per the institutional protocol. Usually, target Modified Ramsay score to 3 or RASS score of –1 to 0.[14,17]

Assessment Tools

Bispectral Index (Bis)[15,18] measures the level of consciousness by algorithmic analysis of EEG. It has Scale 0 (silent EEG) to 100 (fully awake). It is a good tool to use for deep sedation/anesthesia, does not differentiate the level of consciousness for moderate-to-deep sedation.

Awake ECMO

In contrast to the sedated patient, awake patient has multiple advantages on the medical, psychological, and social front. The awake patient has better lymphatic fluid drainage from the lungs with spontaneous breathing as compared with positive-pressure ventilation. They generate better tidal volume due to forced

Table 9: Richmond agitation-sedation scale (RASS)

STAGE I – Observe the patient	If restless or agitated score from +1 to +4. If alter or calm score 0. If not alter progress to stage II	+4	Combative	Overtly combative or violent, immediate danger to the staff
		+3	Very agitated	Pulls on or removes tubes or catheters, aggressive
		+2	Agitated	Frequent nonpurposeful movement, patient-ventilator dysynchrony
		+1	Restless	Anxious but movements not vigorous or aggressive
		0	Alert and Calm	
STAGE II – Assess response from verbal stimulation – state patient name & ask to open eyes and look at the speaker. Repeat if necessary	If response from voice, then assess from -1 to -3. If no response, move to stage III	–1	Drowsy	Not fully alert, awakens and sustains eye-opening, and contact for more than 10 secs
		–2	Light sedation	Awakens and briefly sustains eye-opening, and contact for less than 10 seconds
		–3	Moderate sedation	Any movement in response to voice but no eye contact
Stage III – Physical stimulation by shoulder shake or sternal rub (if safe)	Assess response to physical stimuli	–4	Deep sedation	Movement or eye-opening to physical stimulation
		–5	Unrousable	No response to physical stimulation

Table 10: Advantages of awake patient[17,20]

- Better lymphatic fluid drainage from the lungs
- Better tidal volume due to forced expiration
- Better clinical control in terms of lesser hemodynamic effect, lesser ventilator requirements, and peak pressures
- Better infection control
- Psychological reasons – Patient can communicate with the relatives
  - The patient is able to communicate with the staff about:
    - Changes in body position
    - Body temperature (fever and shivering)
    - Thirst, hunger, and nausea
    - Pain and anguish
    - Outputs (urine and bowel)
    - Neurological control
- Social reasons –
  - Decreases the relative's anxiety
  - Develops some positive attitude

expiration, better infection control, and decreased ventilatory requirement with better hemodynamic controls. The psychological benefit is patients can communicate with the relatives and staff. The patient remains aware about the surroundings and can also actively communicate regarding his problems and dilemmas. Patient participation aids recovery, increased transplant recovery, and decreased postoperative hospital length of stay.[16,19] The social benefit is it decreases the relative's anxiety and helps to develop some positive attitude.

Many times, when the patient is awake, he or she is likely to have some drop in saturation due to increased metabolism. If the patient remains hemodynamically stable, maintaining good urine output, awake, and lactates are acceptable, then we accept lower saturation and prefer to keep the patient awake. One can even increase the ECMO flow (if required) to improve saturation (Table 10).

Extra care is required to maintain adequate flow and prevent accidental decannulation. Also, one should keep a watch on respiratory rate and breathing patterns in order to avoid self-induced lung injury (SILI). Active and passive limb physiotherapy and chest physiotherapy should be encouraged, and if the patient is not able to bring out expectoration, then periodic bronchoscopy is advocated. Communication with the patient should be done by the staff and relatives with respect to his comfort and complaints. For children, it is important to have one of the parents at the bedside most of the time to keep them calm and cooperative. Reading books and telling stories are highly effective in keeping children calm. Let them use all sorts of entertainment like computers, movies, and television to divert their mind.

Summary

ECMO is not painful by itself. Continuous heavy sedation should not be used as sedation does not come without a price.[21] However, achieving optimal levels of sedation to promote comfort, relieve stress, maximise ECMO flows and minimise oxygen consumption, while preventing accidental dislodgement of life-sustaining equipment, can be a difficult balancing act in the setting of altered pharmacokinetics during ECMO. Although the use of minimal sedation and early tracheotomy and ambulation in selected patients has been reported,[22] this is not always possible. Fentanyl and propofol gets coated to circuit hence to be avoided. Muscle relaxant to be avoided as far as possible. It is not just the matter of which sedative agents to use but it is equally important to know do patient needs sedation? Why does he/she need sedation? Can we go without sedation? All these questions need to be answered before giving sedation to the patient.[20] Remember Gentle patient care, friendly talking to the patient and warm assurance to the patient are potent sedatives.

So in short, Sedation Management on ECMO is a risk benefit balance, deep Sedation has risks that appear to outweigh its benefits. Maintaining less to no sedation appears to have benefits but is not without risks. Management of the awake patient is challenging, more resource intensive & requires a dedicated team approach

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