# Clinical Bulletin

IMPORTANT INFORMATION – PLEASE READ AND KEEP

## MIRUS and ECMO

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## Content

Users of the MIRUS system for inhaled sedation of patients are asking for a possibility to use the MIRUS system in combination with an extracorporeal membrane oxygenation (ECMO). For safety reasons, we as the manufacturer of the MIRUS System have not generally approved this combination for use, as the user must be aware of various risks in order to use it safely. In addition, ECMO is to be regarded as an ultima ratio measure and therefore the combination of the MIRUS System and ECMO will not represent the regular use of the MIRUS System.

This article is intended to explain possible combinations of the MIRUS System and ECMO in more detail and to point out risks of the combination.



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## What is ECMO?

ECMO describes the oxygenation of the blood outside the body via a membrane and is a procedure that can partially or completely replace heart and lung function in children and adults. It is used when other treatment methods do not achieve sufficient function of these organs.

In case of a serious disease or lung failure, the oxygenation of the blood and decarboxylation is no longer adequately ensured. In this situation, hypoxia and hypercapnia pose an acute threat to life. If the heart is seriously diseased, the adequate supply of oxygen and nutrients to the organs as well as the removal of metabolic end products can no longer be guaranteed by the limited pumping power, depending on the severity of the disease. The high mortality rate in acute lung failure is mainly due to the combination of aggressive ventilation therapy and high inspiratory oxygen concentrations. As a result, the clinical picture then present can no longer be treated with conventional measures, so that the use of ECMO therapy must be considered as the "ultima ratio".

## ECMO types

Basically, different types of extracorporeal procedures can be distinguished, but they all have the same basic principle. Whereas in veno-arterial ECMO (vaECMO) and veno-venous ECMO (vvECMO) the blood is actively pumped to the oxygenator by means of a pump, in the "pumpless" systems (interventional Lung-Assist "iLA") the blood flows passively through the membrane ventilator.

## The MIRUS System and ECMO

When using the MIRUS system in conjunction with an extracorporeal procedure, the membrane type of the oxygenator plays the most serious role, because the membranes used are permeable to volatile anaesthetics (VA) in different ways.

- Capillary membrane oxygenators have a high,
- Diffusion membrane oxygenators on polymethylpentene basis a low,

permeability for volatile anesthetics.

### General restrictions

- *min $etCO_2$*

The built-in gas monitor in the MIRUS Controller must detect a minimum end-tidal $CO_2$ concentration of > 12 mmHg in expiratory breathing gas.

- *min Delta In/Ex $CO_2$*

The built-in gas monitor in the MIRUS controller must detect a minimum difference of > 8 mmHg between the inspiratory and expiratory $CO_2$ concentration.

### Capillary membrane oxygenator

In use of the MIRUS system, the use of the capillary membrane oxygenator is not recommended, since depending upon the portion of the ECMO flow vs. Cardiac output (CO) and the haematological recovery site used, overdoses may occur due to the system.

- *Capillary membrane oxygenator and vvECMO*

The venous return flow from the body's circulation, in which VA is not washed out, mixed blood rich in $O_2$ and poorer in VA is produced, which is again saturated with VA in the lungs, since the MAC pilot determines and delivers the necessary dosage based on the measured etVA value. In order to reach the set etVA target value, the MAC pilot doses a higher dose of VA concentration measured by expiratory techniques than the target etVA value at the brain. The reason is saturation of the patient to reach the steady-state. The amount of overdose is proportional to the share of ECMO flow in the total CO. If this is e.g. 60%, it can be assumed that 60% of the introduced VA's are also washed out, consequently the dose at the site of action cortex would be increased by 60%, so instead of the set value MAC 1.0 as the real value MAC 1.6.

- *Capillary membrane oxygenator and vaECMO*

For the use of the MIRUS system, a similar statement can be made for the vaECMO as for the vvECMO. Here too, the present "VA leak" for MIRUS can only be detected by the etVA value. As a consequence, there would be a permanent "re-application of VA" by the MAC pilot, which would lead to an overdose at the site of action.

- *Capillary membrane oxygenator and iLA*

In pump-less systems, the extracorporeal portion of the total CO is the lowest of all extracorporeal systems (approx. 20%). On the one hand, the risk for the patient is therefore also lower, and at the same time the resulting overdose of the MIRUS system at the site of action is also lower.

**Diffusion membrane oxygenators on polymethylpentene basis**

A combination of a MIRUS system with an ECMO lung replacement procedure should be preferred to the use of the diffusion membrane oxygenator, as the low permeability to anaesthetic gases such as isoflurane and sevoflurane

- the risks of system-induced overdosage by the MAC pilot of the MIRUS system are greatly reduced;
- the environmental and personnel pollution caused by anaesthetic gas escaping from the membrane oxygenator gas outlet is greatly reduced.

- *Diffusion membrane oxygenators and VA*

Due to the lack of "VA leak", the ECMO application behaves very similar to the conventional ventilation application. The control and regulation systems for the application of volatile anaesthetics in the MIRUS system work in the same way as in "normal" application.

- *Diffusion membrane oxygenators and vv, va, iLA*

The different injection sites (vvECMO, vaECMO) as well as the variance in blood flow volume of ECMO compared to CO (pumped or pump-less (iLA)) still play a significant role for oxygenation and decarboxylation. For the control and concentration of VA at the site of action of the patient this is of minor importance due to the lack of "VA leakage".

- *Diffusion membrane oxygenators and $CO_2$*

The $CO_2$ values of the patient to be measured in the expiratory gas on the ventilation side must be in accordance with the defined minimum requirements for et$CO_2$ (> 12 mmHg) and delta insp$CO_2$ / et$CO_2$ (> 8 mmHg).

## Conclusion

In summary, the use of the MIRUS system in conjunction with various extracorporeal procedures is possible and, especially in view of the advantages of volatile anaesthetics for this patient clientele, certainly makes clinical sense.

The requirements for an ideal sedative, which are described and demanded in the S3 guidelines of the DGAI for analgesia, sedation and delirium management, are largely met by volatile anaesthetics.

When combining the MIRUS system with an ECMO, the attending physician should give preference to the diffusion membrane oxygenator type based on polymethylpentene, as the potential risks of system-related overdosage are low and the risk of indoor air contamination with VA by the outlet gas from the oxygenator is low.

The use of the MIRUS system with an ECMO in combination with a capillary membrane oxygenator is not recommended, since depending on the proportion of ECMO flow vs. CO and the haematological feedback site used, significant overdoses occur at the site of action cortex.

The responsibility for

- the use of the combination MIRUS system and ECMO,
- the adjusted dosage of the anaesthetic gas,
- the adequate clinical monitoring
- compliance with the requirements of the specialist information for anaesthetic gases

is the sole responsibility of the attending physician.

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## Legal notice

This article is not a therapy recommendation, does not remove the restriction on the use of the MIRUS System with ECMO and does not change the purpose of the MIRUS System. The decision to use the combination of the MIRUS System and ECMO is ultimately made exclusively by the attending physician within the scope of his therapeutic freedom.