Support by Technology

Prevent and manage critical incidents in anaesthesia

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THE PROSPECTS AND LIMITATIONS OF TECHNOLOGICAL SUPPORT

Technological advances during the last decades have contributed to great improvements in patient safety. Here, almost the entire range of anaesthesiologic tasks is positively impacted.

Anaesthetic procedure support has improved the safety in airway management through algorithms, video laryngoscopy, extubation catheters, and advanced supraglottic airway devices [28]. In a similar way, ultrasound imaging enhanced the placement of catheters, guidance of needles and the identification of anatomic anomalies for anaesthetic procedures. But especially around the anaesthesia workplace, advancement helped tremendously to either avoid critical incidents or contributed to an improved handling that impacted outcomes.

Even though **technical safety** is something that clinical users might take for granted, it remains extremely important to enable the user to detect and correct technical faults prior to negatively impacting patient care. In a study, Bohnet-Joschko et al. found that the majority of medical technology associated incidents would have been avoided if the devices where properly checked according to the manufacturer's directions[33]. Ideally, technical safety should either prevent a device with a technical flaw from being applied to a patient, but also ensure safe continuation of the treatment until the technical fault is solved or the patient is safely transferred to a

different treatment or device. An example for this is a user friendly, intuitive self-test procedure that encourages the user to regularly perform checks and thus identify technical faults so that they can be fixed before the next case. Another example is the failure of a part or even the entire device. Even though ventilator failure has become extremely rare, it can result into a dangerous situation for the patient if not detected quickly and handled properly. Intelligent fall back solutions provide the opportunity to safely ventilate the patient manually until the case is ended or a spare device has been provided.

Clinician-centric usability on one hand allows the user to use the device more easily and to its fullest potential with respect to performance and safety. On the other hand it remains intuitive even in situations of stress where cognitive reserves diminish. This can affect the adaptation of settings to the needs of the patient and can also bring clinically relevant alarms to the attention of the caregiver while providing him/her with guidance on how to solve the problem.In a study on the usability of modern anaesthesia ventilators, J. Spaeth and collegues compared devices from a human factors perspective. https://www.sciencedirect.com/science/article/pii/S000709121753915X

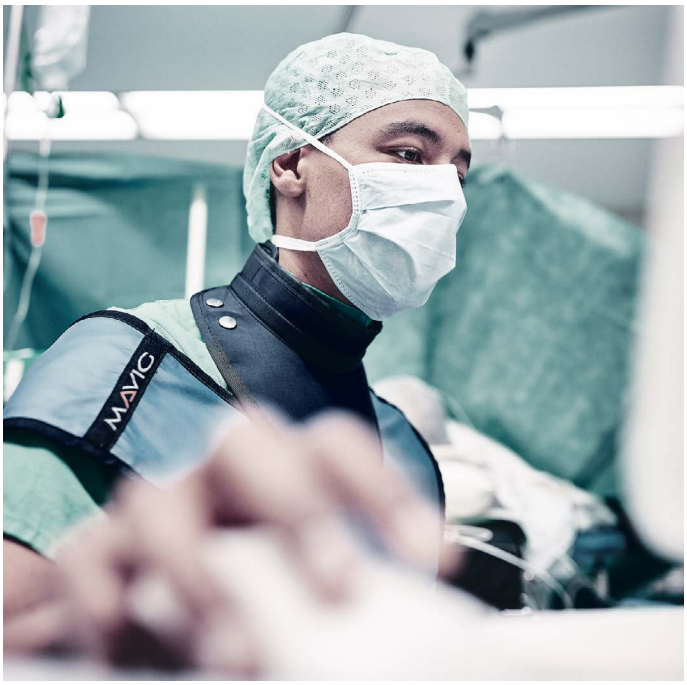
Advanced functionalities in anaesthesia machines provide either more options to protectively treat surgical patients during anaesthesia or enable foresighted safety to prevent critical incidents. To be perfectly honest, this is a huge field with a broad variety of opportunities to improve patient safety. Take for example the advanced ventilation modes, like VolumeControl Autoflow that enables the clinician to set a targeted tidal volume which is then achieved with the least possible pressure in a pressure controlled ventilation pattern. Another example is the availability of a real CPAP in Man/Spont mode supporting spontaneously breathing patients and helping to prevent atelectasis specifically when in supine position.

Data availability is becoming more and more important as medical devices and systems become connected to either exchange data or even become interoperable. The more data become available at the right place at the right point in time, adverse events and critical incidents can be prevented. For example the transfer of patient demographic data from the patient monitor to the anaesthesia device, e.g., the Perseus, enables the anaesthesia device to suggest a protective tidal volume calculated to the ideal bodyweight in order to reduce the risk for postoperative pulmonary complications. Also, statistics available for the entire fleet of anaesthesia devices enable consequent implementation of low-flow anaesthesia reducing volatile anaesthetic usage and thus positively impacting the global warming potential of gases emitted by hospitals.

Assistance systems are the next step to help move the sheer display of data and transforming them into actionable knowledge, so as to support the caregiver with an informed decision. They provide an additional layer of information to reduce the complexity resulting from the sheer mass of data available to the caregiver. Assistance systems can be an integral part of the anaesthesia device, or come as an adjunct to be connected to and mounted in close proximity to the anaesthesia device.

To make it more tangible: Anaesthesia devices that run with low or even minimal fresh gas flow become slow when it comes to changes in FiO_2 or inspiratory anaesthetic gas concentration. The lower the flow, the longer it takes for the change to become effective at the patient. Even though low fresh gas flows can have clinically beneficial effects for the patient, the time until changes in inspiratory gas composition become real appears to many people as incalculable. Assistance systems calculating the projected change of e.g., the FiO_2 or the inspiratory anaesthetic gas concentration over the next 10-20 minutes provide more meaningful information to the user than the sheer fact to what value a parameter was changed. Another example is the dosing of anaesthetic drugs. Especially hypnotics and opioid analgesics, they can't be just dosed according to their pharmacokinetics. The synergistic effect of these drugs is just as important to be factored in. Pharmacodynamic formulas are publicly available, but it appears to be next to impos-

sible to do these calculations in your head. Assistance systems, such as the Dräger SmartPilot View, are capable of doing these calculations online based on dosing data they receive, e.g., from the anaesthesia device or the infusion pumps. The calculated data are then brought into an easy to understand visualisation allowing the caregiver to factor this information together with other data into the dosing regimen.



Automated systems go one step beyond the scope of assistance systems, they automate therapeutic steps based on algorithms. Where the user still needs to manually act upon the provided information when looking at assistance systems, the device takes over this part especially freeing up cognitive resources on the caregiver's side.
One example is an anaesthesia device offering target controlled anaesthesia capabilities. Once a targeted concentration of a volatile anaesthetic has been set, the device automatically controls all relevant parameters to achieve this goal and to keep it in that range. Another example is the target to keep the $etCO_2$ in an proper range. Dräger SmartVentilation control is capable of altering ventilatory parameters to keep the $etCO_2$ in the target range set by the caregiver. Thus, these systems will never make a caregiver redundant, but they free up cognitive resources that will help improve patient centric care and help to manage otherwise emerging critical situations.

We truly believe that the above mentioned areas of technology will be key in preventing and managing critical incidents in the OR and will thus continue to contribute to patient safety. But it is just as important to be aware of some aspects, such complicated technology inherently carries.

What needs to be kept in mind in the management of technology?
While assistance and automated systems decrease the anaesthesiologist's workload and the possibility of human error, technology bears the risk to add even more complexity and overload. Some technologies might even be seen as "black boxes" that leave a taste of uncertainty on the user's side which in turn can result in sub-optimal handling of critical situations.

It is crucial that clinicians have a good understanding of the technological basics of the devices they use. Moreover, that they are extensively trained on how to safely operate/manage these devices and that they know the fall-back options these devices offer. Otherwise, it may prevent the physician to fully understand what the device does during a critical event and prevent him or her from regaining control [29].
An example: An analysis of voluntary incident reports in Germany indicates that proper checks of the equipment to ensure completeness and correct functioning prior to use might have identified and avoided many of the incidents [30]. But instead of blaming the end-users, there should be multidisciplinary efforts to support the physician in doing proper equipment checks: The hospital management and the heads of the departments needs to create the required conditions and provide users ample time to get trained and, just as important, be re-trained regularly via appropriate trainings offered by manufacturers. Also, manufacturers should invest in resources to be responsive at all times so as to respond to questions from caregivers.

Another big impact on the question, if technology improves the situation or worsens it, is the design of the user interface. Poor software design or careless user interface designs have already led to patient harm as they can overload the cognitive capabilities of a user especially in a stressed situation. So the usability of a device in daily clinical practice should be optimised already before bringing it to the market. But there is a high potential of device-related post-market knowledge which can directly promote device innovations and therefore offers benefits to both, the user and the

manufacturer [31]. At Dräger, post-market surveillance, including the usability of the devices, is an important component in the development of innovative devices.

FUTURE OUTLOOK - STAY TUNED AND OPTIMISTIC

The complex and dynamic settings of healthcare, with multiple interdependencies and the requirement for rapid decision-making in uncertain situations, make the anaesthesiologic workplace a challenging environment for the clinical staff [4]. Nevertheless, it should also be stressed that the specialty of anaesthesiology is one with the highest safety record. There are continuous endeavours to even increase this success. Some of these helpful tools are listed above, but this enumeration is not intended to be exhaustive. A meaningful exchange platform for knowledge and best practices is provided by patient safety initiatives, for example the "European Patient Safety Foundation": http://www.eupsf.org/
Also, the national and international professional associations are an important place to go for information of the latest helpful projects in anaesthesiology. In Germany, for example, there are further projects like Net-ra (a project maintaining a database to ensure the quality in regional anaesthesia and acute pain therapy, https://www.net-ra.eu) or OrphanAnaesthesia (an international project to create anaesthesiological recommendations on rare diseases, https://www.orphananesthesia.eu/de/).

Systemic changes are of utmost importance like the implementation of an open error culture; including patient safety as a key topic in education; putting this safety at the top of the agenda of hospital management; or changing the definition of safety from "avoiding that something goes wrong" to "ensuring that everything goes right".

WHICH FURTHER TOPICS ARE IMPORTANT TO DISCUSS?

There are still questions left to think about: Is it possible to handle the rising complexity even with the available tools? Will artificial intelligence provide a helpful tool to increase patients' safety? Are the specialists optimally trained and educated to deal with complexity? How can we handle the balance between safety and efficiency? Is the system able to change its mindset in the near future? How can teamwork in a multidisciplinary team be facilitated?

While the development of these system changes will take some time, what can be done in the meantime? How can the anaesthesia staff be supported and what kind of new tools are available? This is not just the focus of the present article, but will also be the topic of subsequent articles and reports on this website.

Not just the general tools need our attention, but there are also a variety of common critical events in anaesthesia that should be discussed like leakages, hose mismatches, residual neuromuscular blockade (NMB), unintended awareness or a missed or inappropriately performed self-test of the anaesthesia device.

The anaesthetic environment is getting more and more complex. But helpful tools are being implemented and safety culture is growing. Patient safety is crucial in every circumstance, in all cases – as is the well-being of the anaesthetic team.

> "Just as complex systems threaten to bring us down
> ... so do complex systems bring
> us unimagined and probably undeserved bounty." [32]

In our article on critical incidents in anaesthesia, we reviewed relevant literature and discussed with renowned experts to provide an overview. For references and details, please visit our website:
www.draeger.com/patient-safety

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