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Master thesis | Original study

Safety and reliability of inhalational anesthesia for disaster medicine: the use of the Glostavent® Helix in Turkey in the aftermath of 2023 earthquake, a case-series

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Abstract

Background: **While it has already been demonstrated that anesthetic care can and should be used in disaster medicine, inhalational anesthesia can be a challenge, given its logistical footprint.**
After the 2023 earthquakes in Turkey, Belgium decided to send a field hospital with emergency surgical capacity (EMT type 2). The Health Federal Public Service provided the CE approved Glostavent® Helix for this mission. This open circuit anesthesia machine is able to work on battery or AC power, to operate on with oxygen cylinder or only with its integrated oxyconcentrator, to use different types of halogenated anesthetics vapors, in particular in "draw over" mode and to ventilate an adult or pediatric patient.
Objective: **The aim of this article is to describe the reliability and safety of inhaled anesthesia via the Glostavent® Helix in a context of disaster medicine.**
Methods: **We conducted a retrospective case-series study. All patients who underwent general anesthesia at our field hospital during the period 16 February till 25 February 2023 were included. We did not establish any exclusion criteria. The primary endpoint was mechanical failure during the procedure. Secondary endpoints were perioperative desaturation (SpO2<94%), ventilation failure (ETCO2 > 45mmHg) and awareness.**
Results: **We performed 62 surgical procedures including 19 under general anesthesia.**
Maintenance of anesthesia has always been done with sevoflurane. The average operation time was 56 min (SD: 38,32), the cumulated time 1055 min. We performed 4 inhalation inductions in our pediatric population. All supplied fresh gases were generated by the oxyconcentrator. There were no critical failures of the Glostavent® Helix. No patient underwent desaturation. Only one patient was transiently inadequately ventilated. No patients reported any awareness.
Conclusions: **Our Glostavent® Helix was fully operational in this setting. In comparison, our other CE approved medical machines (X-ray and sterilization unit) regularly broke down due to AC variations. It was also self-sufficient in terms of oxygen supply. We experienced only one transient failed ventilation due to a partial airway obstruction in a prone obese patient, noticed with delay due to lack of tidal volume alarm.**
Although it requires thorough knowledge of its operation and continuous clinical attention, the Glostavent® Helix offers a simple but elegant, reliable and safe solution.

Keywords: **Disaster medicine, earthquake, inhalation anesthesia, mechanical ventilator.**

Presentation: The abstract of this article was presented during the 2023 Besarpp graduation day on the 10th June 2023 and received the second place for best abstract award.
Ethics: Given the emergency context in an austere and isolated environment, as well as the language barrier with Turkish or Arabic speaking patients, it was not possible for us to obtain state of the art informed consent and advice from Belgian ethical committee before departure. Nevertheless, both the study protocol and the article itself were presented to the Onze Lieve Vrouw Ziekenhuis Aalst ethics committee. On 24/07/2023, the ethics committee chaired by Dr. A. Leloup noted no objections to publication of this article, study number 2023/095.
Inclusion period :16 February 2023 to 25 February 2023.

Introduction

Background: Turkey earthquake

On February 6, 2023, an earthquake of magnitude 7.8 hit Turkey and Syria at 04:17 AM.

The death toll in human life will be extremely high in Turkey alone. United Nations Office for the Coordination of Humanitarian Affairs (OCHA) report estimates the number of deaths at 50,000 as of April 13, 2023. More than 107,000 people were injured according to the same report[1].

The infrastructure of many hospitals has been affected. In response to the outbreak of casualties and the temporary collapse of health care services in the affected areas, many countries offered their assistance to Turkey.

Unlike other countries which favored rapid action in the short terms by sending rescue teams, Belgium preferred to provide medium term aid by deploying a field hospital Emergency Medical Team Type 2 (EMT type 2) under the responsibility of inter-departmental Belgian First Aid & Support Team (B-FAST) organization. Construction began on February 12, 2023.

It was fully operational from 16 February 2023 till 9 March 2023. A total of 3503 patients were treated during these 22 days[2].

The Belgian Health Federal Public Service provided the CE (European conformity) approved Glostavent® Helix anesthesia device for this mission.

EMT Type 2: Inpatient surgical emergency care

In order to coordinate and standardize the assistance of the different nations, the World Health Organization (WHO) has established in 2013 different levels of care and has described minimum standards[3].

The EMT type 2 is the most forward structure with surgical capacity.

An EMT type 2 consist of one triage tent, one outpatient department, one emergency area, two inpatient wards, one gyneco-obstetrical tent, one pediatric tent and must have at least one operating room for surgical management of trauma and obstetric procedures.

It must be capable to perform 7 major or 15 minor surgical procedures a day.

Safe procedural sedation, but also general, regional, and spinal anesthesia must be available for both pediatric and adult population.

Logistically, any EMTs should be as self-sufficient as possible. Electricity supply must be assured, and UPS uninterruptible power supply (UPS) must be available for life saving equipment such as ventilators and anesthesia workstations.

Anesthesia in disaster medicine

Working conditions in developing countries or disaster areas are not standard for most anesthesiologists.

Logistical, environmental, and economic circumstances are additional parameters to consider when establishing our anesthetic strategies. Likewise, the anesthesia equipment should be adapted to these circumstances.

Local anesthesia, loco-regional anesthesia, spinal anesthesia, and procedural sedation have a preponderant place in precarious environments due to their relative safety and small logistic footprint[4,5]. Nevertheless, general anesthesia is sometimes crucial and should be the standard of care. In this setting, ketamine has often been described as the drug of choice, although it most often only allows sedation for small surgery or short term procedures[6–8].

Inhaled anesthesia brings logistical difficulties concerning its implementation on the field[6,7,9].

A conventional anesthesia workstation requires an uninterrupted supply of electricity, mechanical ventilation, oxygen and pressurized air, means of vaporizing halogenated gases, and an exhaust system for exhaled gases.

Some theoretical points must be recalled to better understand how the Glostavent® Helix responds to the challenges of inhaled anesthesia in disaster medicine.

Inhalation anesthesia

The debate about the superiority of inhalation anesthesia over iv anesthesia (or vice versa) is completely outside the scope of our study. We can, however, outline some of the advantages of having halogenated gases in our therapeutic arsenal.

Advantages

Spontaneous ventilation

Used at surgical doses, halogenated gases still allow spontaneous breathing. Even when used in supratherapeutic doses, sevoflurane only slightly reduces minute-ventilation and ventilatory response to hypoxia[10]. Most other hypnotics, such as benzodiazepines or propofol, induce apnea if used at the doses intended for surgery. Working with spontaneous ventilation can bring several advantages: reduced barotrauma, better hemodynamic stability compared with mechanical ventilation thanks to negative pressure, reduced leakage from laryngeal masks, preserved ventilation and oxygenation during induction of anesthesia or ENT instrumentation...

Minimal alveolar concentration (MAC)

If their pharmacodynamics have not yet been explained, the use of halogenated gases and their clinical effects are well known to anesthesiologists through the notion of MAC. In a very predictable way, the alveolar fraction (Fa) are linked to different clinical targets (MAC BAR, MAC and Mac Awake).

Pediatrics

While spinal, epidural, and loco-regional anesthesia in pediatrics is increasingly described in the literature, these are more often for analgesic purposes. They are almost always associated with sedation or general anesthesia[11]. Similarly, if total intravenous anesthesia induction (TIVA) and maintenance of anesthesia in pediatrics are possible[12], most anesthesiologists are more confident to use halogenated gases[13,14].

Disadvantage

Environmental considerations

Halogenated gases are well-known pollutants. Isoflurane and halothane deplete the ozone layer. Sevoflurane and desflurane contribute to global warming by absorbing infrared thermal energy[15]. The ecological impact, secondary to the major humanitarian problems on site, could be reduced by the use of sevoflurane scavengers such as CONTRAfluran™ (Baxter). This would, however, impose an additional logistical challenge.

Anesthesia workstation

An anesthesia machine has basically 3 functions: it must be able to oxygenate, ventilate and sedate our patient.

Oxygenation

The composition of the fresh gas can be done by 2 main methods; either the oxygen and air (and possibly nitrous oxide) come from pressurized sources (oxygen cylinders, wall gas); or oxygen and air are extracted via an oxyconcentrator and then pressurized.

Ventilation

The ventilation of the different anesthesia machines can be done in two ways. Either by pneumatic power source or by electric power source[16].

Pneumatic power source (concertina, "double circuit") uses the gas pressure delivered by the different sources to ventilate the patient. The oxygen or air under pressure acts as a piston. The fresh gases, separated from the pressurized gases by a membrane, are expelled towards the patient by the pressure. Pressurized gas is thus at all times needed for this mode. The control of the ventilation parameters is mainly electronic and requires a minimal electric power source.

In electric power source, a piston or a turbine exerts the necessary pressure to set the fresh gases in motion. Pressurized gases are therefore not required for the working of the ventilation system. However, a more important electrical power source is required.

Sedation

Likewise, in order to sedate our patient, an anesthesia machine must be able to vaporize halogenated gas and administer it to the patient at configurable percentages.

Vaporizers can also have different modes of operation.

In variable bypass vaporizer, a part of the carrier gas bypasses the vaporization chamber, another part passes through the chamber and saturate. The two parts are mixed afterwards. The desired concentration of halogenated gas is obtained by simply modulating the proportion of carrier gas bypassing the chamber[17].

Variable Bypass Vaporizers can have high or low resistances.

High resistance vaporizers have the advantage of producing a much more predictable output regardless of the carrier gas flow rates passing through them. However, they require an upstream pressure to operate (Plenum vaporizers). Their high resistance also imposes that they are built outside the anesthetic breathing circuit. Therefore, they cannot be used in simple non-pressurized breathing circuits[17].

Low resistance vaporizers can work with negative pressure, e.g., from the patient's spontaneous breathing (draw-over vaporizers). Their low resistance allows them to be inserted directly into the anesthetic breathing circuit. The disadvantage is that they are less predictable in terms of the produced concentration of halogenated gases during ventilation, especially, at very low or very high minute volumes[17].

Newer anesthesia workstation uses other types of vaporizers than the traditional variable bypass vaporizer such as Fuel injectors or Aladdin cassettes. They differ so much from the Glostavent® Helix vaporizer that their understanding is outside the scope of this article.

Finally, anesthesia machines can consist of an open or closed circuit.

Closed circuit-machines have the advantage of "recycling" exhaled gases by reinjecting them into the anesthesia circuit. In these circuits, the gases produced by the patient (CO2) are absorbed and the

gases absorbed by the patient are compensated (O2 + halogenated gas)[16,18].

Although these circuits allow a drastic reduction in the quantity of halogenated gases consumed, they add new logistic constraints. CO2 is captured by soda lime which must be replaced regularly. The reinjection and mixing of exhaled gases with fresh gases also requires a continuous analysis of inhaled gases in order to avoid hypoxic and/or subtherapeutic mixtures.

Glostavent® Helix

The Glostavent® Helix is a CE certified open circuit anesthesia machine.

It has a built in oxyconcentrator and compressor capable of delivering 10 liters per minute of theorically 95% oxygen (5% argon) and 10 liters per minute of air, both pressurized at >20 pound per square inch (psi).

It has a pneumatic power source ventilator whose operation requires about 1/6th of the Volume Minute of pressurized oxygen[19].

It has a low resistance variable bypass vaporizer capable to work in plenum mode if pressurized gases are available, or in draw over mode if they are not available.

The workstation weighs 102kg, measures 54 x 66 x 145cm and its UPS battery is capable of handling varying voltages and frequencies (110-330 AC 45-65Hz). In the event of a power failure, the Glostavent® Helix can operate the oxyconcentrator and ventilator for 30 minutes, the ventilator alone with an emergency air compressor for 12 hours and the ventilator with an external supply of pressurized oxygen for 300 hours[19].

Objective

The objective of this case series is to describe the reliability and safety of inhaled anesthesia via Glostavent® Helix during the deployment of the Belgian B-FAST EMT type 2 in Kirikhan (Turkey) in 2023, following the earthquake of February.

Method

Study design

We performed a retrospective consecutive case-series study including all patients who were provided with general anesthesia in our EMT Type 2 during the first wave of our deployment (February 17, 2023 to February 25, 2023) in Kirikhan, Turkey.

The medical data were searched in the preoperative, intraoperative, and postoperative medical records. The collection of information on the follow-up of the patients was therefore limited to the data recorded in the direct postoperative phase in the recovery room.

There were no exclusion criteria.

We considered different parameters: Patient's age, urgency or elective nature of the procedure, surgical indication, procedure time (minutes), patient positioning (supine, prone, lateral, gynecological), type of induction (Intravenous vs. Halogenated gases vs. others), type of anesthesia maintenance (Intravenous vs. Halogenated gases), anesthesia machine (Glostavent® Helix vs ZOLL Emergency medical ventilator). In addition, we also looked for the modes of use of the Glostavent® Helix during these surgical procedures (electric current vs. battery vs. no electricity, oxygen via oxyconcentrator vs. oxygen cylinder).

We looked for technical failure of the Glostavent® Helix that required the use of a backup machine to ventilate and/or sedate our patients as the primary endpoint.

Our secondary endpoints were medical complications that can be linked to a non-optimal functioning of the Glostavent® Helix: desaturation defined by SpO2 (peripheral capillary oxygen saturation) <94%, Hypercapnia defined by EtCO2 (end-tidal carbon dioxide partial pressure) >45mmHg, hemodynamic instability not explained by the homeostasis of the patient (use of vasopressor not predicted by patient disease), delay of recovery (>15 minutes for extubation, prolonged sedation >1h in recovery room), intraoperative awareness (reported by hetero anamnesis via the translators).

Statistics

For numerical values, we performed arithmetic means, modes, and medians.

Primary and secondary endpoints were expressed as absolute values or as percentages.

Standard derivations of the means were calculated to describe the dispersion.

Reporting

This manuscript adheres to the applicable STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines.

Ethics

Given the emergency context in an austere and isolated environment, as well as the language barrier with Turkish or Arabic speaking patients, it was not possible for us to obtain state of the art informed consent and advice from Belgian ethical committee before departure. Nevertheless, both the study protocol and the article itself were presented to the Onze Lieve Vrouw Ziekenhuis Aalst ethics committee. On 24/07/2023, the ethics committee

chaired by Dr. A. Leloup noted no objections to publication of this article, study number 2023/095.

Results

During the deployment period, we performed 62 surgical procedures.

- 28 under procedural sedation (45%).
- 7 under spinal anesthesia (11%).
- 8 under loco-regional anesthesia (13%).
- 19 under general anesthesia with airway management (30%).
  - Both laryngeal masks and oro-tracheal tubes were used.

Medical documentation was available for all 19 patient who underwent general anesthesia.

The total cumulative time under general anesthesia was 1055 minutes.

The average operating time under general anesthesia was 56 minutes.

The minimum intervention time was 15 minutes; the maximum intervention time was 150 minutes.

During the whole period, the electricity supply was produced by the generators of the EMT type 2.

We did not observe any critical failure of the Glostavent® Helix that required switching to back-up ventilation or sedation.

Fresh gas production by the oxyconcentrator was sufficient for the entire cumulative time. The oxygen cylinder, available in case of malfunction, did not have to be used.

We provided general anesthesia to 7 pediatric patients (37%) from 2 years and 2 months old to 15 years old. We performed 4 inhalation inductions (57%) and 3 intraveinous inductions (43%) with inhalation maintenance for these children.

We used sevoflurane to maintain the anesthesia in all our procedures.

No patient underwent desaturation.

We report 1 patient (5%) with transient EtCO2 > 45mmHg during mechanical ventilation.

No patient suffered from unexpected hemodynamic instability or delayed recovery after anesthesia.

No patients reported any awareness.

Discussion

General considerations

The proportion of general anesthesia performed during our deployment is much greater than that reported from Doctors Without Borders missions (30% vs 9%)[6]. In fact, our practice was more similar to the care reported by the regional public hospital Rumah Sakit Umum Daerah Provinsi Nusa Tenggara Barat (RSUD NTB) in Indonesia after the 2018 earthquakes[20]. Having a reliable source of oxygen most certainly influenced our anesthetic strategy.

The high prevalence of pediatric cases (37%) during our deployment corresponds to a well-described trend in disaster medicine[9].

Having inhaled anesthesia allowed us to work in comfortable and familiar circumstances (vide supra “advantages of inhaled anesthesia”).

Table I. — Summary table : Main results.

General anesthesia with airway management	N=19
Time	
Total cumulative time (min)	1055
Average operating time (min-SD)	56-36,32
Minimum intervention time (min)	15
Maximum intervention time (min)	150
Pediatric population (n ; %)	7 (37%)
Minimum age	2 years and 2 months
Inhalation induction (n ; %)	4 (57%)
IV induction (n ; %)	3(43%)
Primary outcome: Critical failure (n)	0
Necessity to use other ventilator	0
Necessity to use of other sedation mode	0
Sevoflurane maintenance of anesthesia (n;%)	19 (100%)
Secondary outcome :Perioperative complications (n)	1
SpO2 <94% (n)	0
EtCO2 >45mmHg (n ;%)	1 (5%)
Hemodynamic instability (n)	0
Delayed recovery (n)	0
Awareness (n)	0
Retrospective data from the use of the Glostavent® Helix during the first rotation of the B-Fast mission in Kirikhan (Turkey) after the 2023 earthquake	

Primary endpoint: Reliability

During the whole mission we did not notice any technical failure of the Glostavent® Helix that required the use of a back-up (zoll Emergency medical ventilator or bag valve mask).

This is mainly due to the fact that the power supply of the EMT type 2 was never interrupted. However, the variable quality of the power supply led to the malfunction of our X-ray machine (RX AGFA DX-100+) and our sterilization unit, putting them both out of service for a day. Their repair required specialized personnel and spare parts not available within the EMT. On the contrary, the Glostavent® Helix, capable of withstanding voltage and frequency variations :110-330 volts alternative current (AC) 45/65Hz, does not seem to have suffered[19].

It is also interesting to notice that we never had to use an oxygen cylinder. During the whole period the oxyconcentrator and the air compressor provided enough fresh gases to fulfill the mission, although the measured FiO2 was never above 86%.

Depending on local costs, using the oxyconcentrator could cost only 1% of the price of oxygen cylinder needed to provide the same amount of oxygen[19].

Even if we had had electricity supply failures, we could theoretically calculate the repercussions that this could have had on the mission.

In case of power failure, the UPS battery can last for 30 minutes (oxyconcentrator, compressor and ventilator control)[19]. This would have allowed us to complete most of the surgeries and to wake up our patient.

If a longer power outage was to be expected, other battery conservation strategies could have been chosen.

The battery of the Glostavent® Helix is capable to supply electricity to compress air to operate the ventilator (pneumatic power source) for a period of 12 hours[19]. This corresponds to 68% of the total intervention time reported over the period (1055 min). Note that the FiO2 would have been only 21%.

In another way, we could have used a pressurized oxygen source to generate the necessary pressures for mechanical ventilation. In this mode, the power consumption is minimal, and the manufacturer claims a battery life of over 300 hours[19]. It has to be noticed that the quantity of oxygen would become the limiting factor.

Let us recall that the quantity of oxygen necessary to produce a ventilation pressure is about 1/6th of the minute volume so we can estimate that it would have been about 1L/min. To increase the FiO2, an additional flow would have been necessary. By adding 2l/min, we could have obtained a FiO2 of about 47% in a patient with a minute volume of 6l/min ((4x0.21)+2)/6). With a 10l oxygen cylinder at 200 bar (2000l O2), we could have theoretically ventilated patients at 6l/min minute volume with a FiO2 of 47% during 666 min (2000/(2+1)). This corresponds once again to 63% of the total intervention time of the mission.

Finally, we could also have decided to perform anesthesia without the ventilator and to ventilate our patients by hand. Since the draw-over vaporizer does not require electricity for its operation, we would have been limited only by our sevoflurane stock.

Let's compare it with the Drager Fabius Tiro which is the standard anaesthesia workstation of the Belgian Defense Field Hospital Role 2.

It is a closed-circuit anesthesia workstation with a plenum vaporizer.

Its integrated UPS battery allows an operation of 45 minutes to 2 hours maximum in case of power failure[21]. Spontaneous and manual ventilation remains always possible in case of power failure.

By being an electronic power source (piston) ventilator, it can continue ventilating the patient in case of fresh gas supply failure. However, the FiO2 will decrease as the patient consumes the oxygen in the closed circuit. This risk of obtaining a hypoxic mixture therefore only allows very temporary ventilation.

Secondary endpoint: Safety

We had 1 transient ventilation failure.

The ventilator of the Glostavent® Helix use an intermittent positive pressure ventilation (IPPV) / maximum volume mode.

The settings of the device are therefore adjusted by modulating the maximum pressure and the maximum volume.

In this case, partial obstruction of the endotracheal tube of our prone patient prevented the anesthesia workstation from reaching the tidal volume that we had set. Although the ventilator has a high-pressure alarm, it does not have an alarm when the tidal volume is not reached. However, this is easily observable as the concertina does not go all the way down. As soon as the origin was identified (bent endotracheal tube) and corrected, the patient's ventilation was adequate.

We emphasize that a good understanding of the Glostavent® Helix and continuous clinical attention are necessary in order to have an optimal implementation.

None of our patients reported any awareness.

This fact, possibly underestimated (see bias), can be explained by the ease of use of halogenated gases.

For each intervention, the vaporizer was

configured so that the concentration of inhaled gases corresponds to a minimum of 2x the awake MAC (0.7 MAC). This ensures that 99.9% of our patient won't have any awareness18.

However, as we did not have a halogen gas analyzer, we had to make two approximations. The first was that the percentage set on the vaporizer (Fd sevoflurane: delivered fraction sevoflurane) was equivalent to the percentage of inspiratory fraction (Fi) sevoflurane. The fact that the Glostavent® Helix is an open circuit with a high carrier gas flow rate makes this approximation more acceptable. Nevertheless, let us recall that low resistance vaporizers perform poorer at very low or very high gas flows.

The second approximation was that Fi ≃ Fa. However, this approximation is only valid at steady state.

Even if we were not able to estimate the Fa before steady state, this did not have any clinical implication since the drugs injected during the induction ensured the sedation of our patient during this time.

In comparison, one study described up to 20% awareness during urgent surgeries performed under ketamine[22]. While the circumstances of this study are not comparable to those available to us during our deployment (ketamine was primarily delivered by non-anesthesiologists), we cannot assert that the results would have been different with specialized personnel. Most anesthesiologists are not trained to provide general anesthesia with ketamine only.

Comparaison previous experience inhaled anesthesia for disaster medecine

We were able to find only one study describing the use of an anesthesia workstation (Universal anesthesia machine: UAM) in disaster situations (US army, Haiti 2010)[23]. Unlike the UAM, the Glostavent® Helix has a mechanical ventilator. The results obtained with the Universal anesthesia machine are comparable (no complications). Interestingly, unlike in our rotation, no children received general anesthesia during their mission.

Bias

The medical documentation at our disposal is limited to the direct postoperative follow-up in the recovery room. Although this follow-up period is very short, it does cover most postoperative complications. Still, late postoperative complications that could have been linked to our anesthesia could not be evaluated (for example postoperative delirium).

The accuracy of the sevoflurane concentration delivered could not be verified during the mission. The necessary monitoring was not available. We therefore tried to estimate the risk of sevoflurane overdosis by notifying the potential consequences (delayed recovery, hemodynamic instability).

Awareness may have been underestimated due to the language barrier and the fact that signs would have been reported only if they had been expressed by the patients. Nevertheless, the constant presence of our translators during the mission reduces this risk of underestimation.

Generalizability and conclusion

We recognize that the deployment of our EMT Type 2 does not necessarily fit all disaster medicine situations. We had a substantial logistical support enabling the transport of our anesthesia machine and the supply of electricity. Nevertheless, under these circumstances, the Glostavent® Helix allowed us to work reliably and safely during our deployment in Turkey. It could be a real asset when electricity is available but oxygen supply is difficult to guarantee.

Abbreviations

- AC = alternative current
- B-FAST = Belgian First Aid & Support Team
- CE = conformité européenne (European conformity)
- EMT Type 2 = Emergency Medical Team Type 2
- ETCO2 = end-tidal carbon dioxide partial pressure
- Fa(x) = alveolar fraction (x)
- Fd(x) = delivered fraction (x)
- Fi (x) = inspiratory fraction (x)
- FiO2 = O2 inspiratory fraction
- IPPV = Intermittent positive pressure ventilation
- MAC = minimal alveolar concentration
- OCHA = United Nations Office for the Coordination of Humanitarian Affairs
- PSI = pound per square inch
- RSUD NTB = Rumah Sakit Umum Daerah Provinsi Nusa Tenggara Barat (Provincial General Hospital Indonesia)
- SpO2 = peripheral capillary oxygen saturation.
- STROBE = STrengthening the Reporting of OBservational studies in Epidemiology
- TIVA = total intravenous anesthesia
- UPS = uninterruptible power supply
- WHO = World Health Organization

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