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Practice of Mechanical Ventilation in the Intensive Care Unit of the Reference Hospital in Maradi

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Abstract

Introduction: Mechanical ventilation is a technique that assists or replaces breathing using a device called a ventilator or artificial respirator. The aim of this study was to evaluate the practice of mechanical ventilation in the intensive care unit of the Maradi referral hospital.

Methodology: This was a descriptive, cross-sectional, retrospective study covering a three-year period from July 1, 2021, to June 30, 2024,

conducted in the intensive care unit of Maradi Referral Hospital, focusing on patients who underwent mechanical ventilation.

Results: During the study period, 133 patients out of a total of 489 were recorded with a VM frequency of 27.19%. The average age was 40.79±19.25 years (range 4 to 87 years) with a sex ratio of 3.29 in favor of males. Invasive ventilation was more commonly used (99%) than NIV, with the main indications being disorders of consciousness (47.4%), followed by respiratory distress (29.3%). Volumetric mode was used more than barometric mode (84% vs. 16%). Sedation-analgesia was necessary in 98% of patients and consisted mainly of midazolam and fentanyl. The average duration of ventilation was 6±5.3 days. PAVMs were the main complications associated with mechanical ventilation (89.5%). The mortality rate was 77%.

Conclusion: Mechanical ventilation is increasingly common in our department, with a high mortality rate. It is mainly indicated for severe head injuries.

Keywords: Mechanical ventilation, Resuscitation, Disorders of consciousness, Ventilator-associated pneumonia, HRM, Niger

Introduction

Mechanical ventilation (MV) is a technique that assists or replaces breathing using a device called a ventilator or artificial respirator (Diop et al., 2023). It ensures optimal gas exchange in patients suffering from acute respiratory failure, significant impairment of consciousness, or during general anesthesia (Diop et al., 2023). It provides essential support to improve oxygenation in cases of respiratory distress, but can also exacerbate lung damage in weakened lungs (Thille et al., 2005). Mechanical ventilation is increasingly common in intensive care units and now plays an important role in the therapeutic treatment of severe respiratory and neurological failure.

Globally, the number of patients requiring mechanical ventilation (MV) has continued to increase in recent years (Petit et al., 1993). In 2010, a study conducted at the Dakar Military Teaching Hospital revealed that of the 826 patients hospitalized during the study period, 237 had received mechanical ventilation, representing an incidence of 28.69%, with a favorable outcome in 33.33% of them (Wade et al., 2011). Then in 2013, Diakité O.S. and colleagues reported a ventilation incidence of 55.4% among comatose patients in Mali (Diakité, 2013). In 2015, a study conducted in India on the incidence of MV revealed that out of 500 patients admitted to intensive care units, 130 were treated with mechanical ventilation, i.e., 26% (Khatib et al., 2018).

Although mechanical ventilation has many advantages, poor management by practitioners can lead to lung damage and serious hemodynamic disorders.

However, there are still many uncertainties regarding its use in intensive care.

In Niger, there are no precise data on mechanical ventilation. It is an increasingly common practice in the intensive care unit of the Maradi referral hospital.

This led us to initiate this study with the aim of assessing the epidemiological, clinical, and prognostic aspects of patients who have undergone MV in the intensive care unit of the Maradi referral hospital.

Patients and Method

This is a descriptive,cross-sectional retrospective study conducted in the intensive care unitof the Maradi referral hospital from July 1,2021, to June 30, 2024.All patients admitted tointensive care who received mechanical ventilation were included in the study. Patients who were intubatedand extubated in the operating room, as well as patients with unusableor incomplete medical records, were excluded from this study. The study examined socio-epidemiological and clinical variables,reasons for admission to intensive care, indications for mechanical ventilation, modes of MV used, different types of MV,anesthetic drugs administered during induction of anesthesia and maintenance ofsedation, duration of mechanical ventilation, complications related to MV, and patient outcomes.Thedata were collected on survey forms that we made availablein the department, based on medical records. Thecollection and analysis were performed using SPSS version 27.0.1 software,Pearson's Chi2 test/Fischer's exact test $P < 0.05$.Thedata was tabulated using Microsoft Office Excel 2019.Word processing was performed using Microsoft Office Word 2019.Thisstudy was conducted with the approval of the administration of thereference hospital in Maradi, as well as the patients' legal representatives. Theinformation collected remains confidential.

Results

Sociodemographic aspects:

During the period of our study, 489 patients were admitted to the intensive care unit of the Maradi referral hospital, 133 of whom had received mechanical ventilation, representing a frequency of 27.19%. They were male in 77% of cases (102), representing a sex ratio of 3.29. Their ages ranged from 4 to 87 years, with an average of 40.79±19.25. Patients aged 30 to 60 years were the most represented, accounting for 45.1% of cases.

Clinical aspects:

A history of medical conditions was reported in 23 of our patients. Hypertension was the most common condition, as shown in the table below.

Table I: Distribution according to type of medical history

Medical conditions	Frequency	Percentage
None	**105**	**82.7**
Heart disease	4	3.0
Heart disease/hypertension	1	0.8
Diabetes	4	3.0
Diabetes/hypertension	2	1.5
Hypertension	**12**	**9.0**
Surgery	5	3.8
Total	133	100.0

The patients came from a wide variety of locations. Two patients from the Mother and Child Health Center (MCHC) were admitted directly. Emergency departments were the main source of patients, as shown in Table II.

Table II: Distribution by department of origin

Department of origin	Frequency	Percentage%
Surgical emergencies	**80**	**60,2**
Operating room	1	0,8
Cardiology	2	1,5
MCHC	2	1,5
Internal medicine	1	0,8
Postoperative	**20**	**15,0**
Medical emergencies	**27**	**20,3**
Total	**133**	**100,0**

Patients came from the surgical emergency department in 60.2% of cases (n=80).

Admission to the intensive care unit was due to a variety of causes. The main causes were severe head trauma, non-traumatic altered consciousness, multiple trauma, and respiratory distress. The table below provides more details.

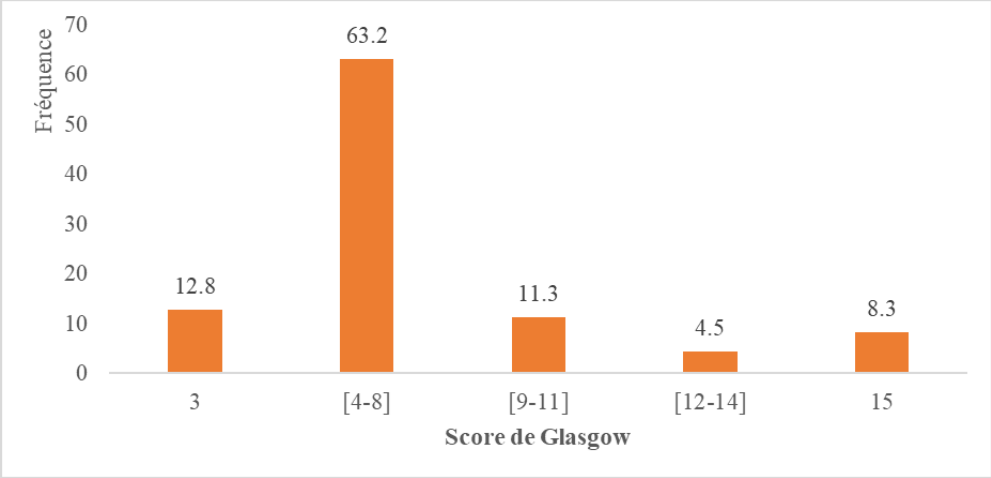
Table III: Distribution according to reason for admission

Reason for admission	Frequency	Pourcentage%
Severe head trauma	**43**	**32,3**
Ketoacidosis	2	1,5
Altered consciousness	**18**	**13,5**
Cardiorespiratory arrest	9	6,8
Stroke	5	3,8
Severe burns	6	4,5
Respiratory distress	**15**	**11,3**
Septic shock	1	0,8
Status epilepticus	3	2,3
Necrotizing fasciitis	7	5,3

Meningoencephalitis	2	1,5
OAP	1	0,8
Severe malaria	3	2,3
Acute pancreatitis	1	0,8
Multiple trauma	**17**	**12,8**
Total	**133**	**100,0**

Patients admitted for severe head trauma, cardiopulmonary arrest, stroke, respiratory distress, severe malaria, and certain types of multiple trauma presented with altered consciousness, but at varying stages. In this context, 75 patients presented with altered consciousness, for a total of 118 cases of altered consciousness from all causes. Figure 1 provides more details on the patients' state of consciousness.

Figure 1: Distribution of patients according to Glasgow Coma Scale score on admission to intensive care



Approximately 63.2% (n=84) of patients had a Glasgow Coma Scale score on admission between [4-8].

Practice of mechanical ventilation

The main indications for mechanical ventilation were impaired consciousness, respiratory distress, severe head trauma, and cardiopulmonary arrest. The proportions of these conditions are shown in Figure 2.

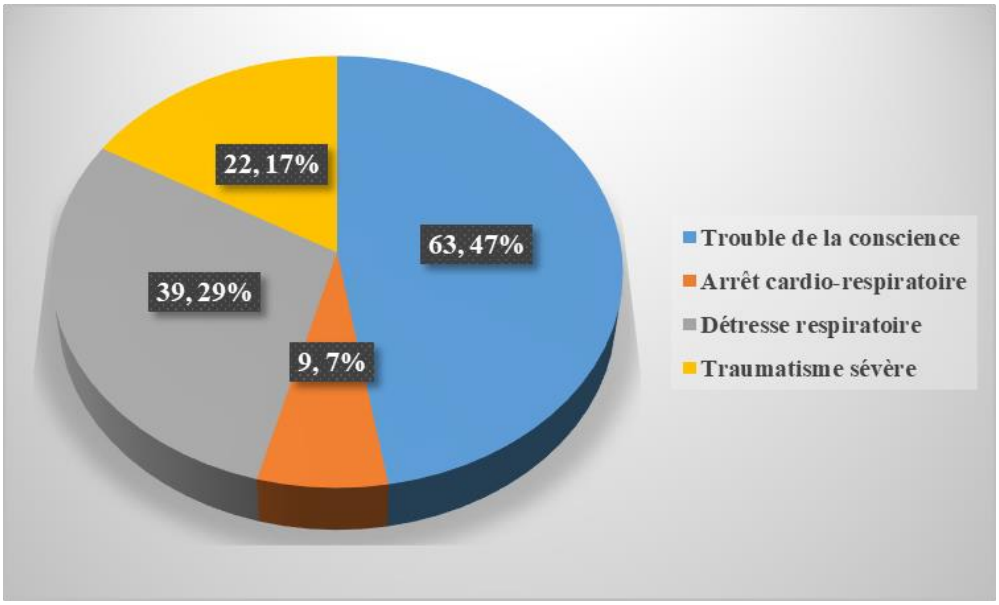


Figure 2: Distribution according to the indication for mechanical ventilation

For the implementation of mechanical ventilation, anesthesia was performed in 94% of patients. To do this, the following hypnotics were administered: Propofol (75.2%), Thiopental (21.6%), Ketamine (2.4%), and Hypnovel (0.8%). As for morphine derivatives, only fentanyl was administered. Curare was used for intubation in 74 patients (56%), of whom 71 received Suxamethonium and the remaining 3 received Vecuronium. The airway management techniques used were orotracheal intubation (98.5%), face mask (0.8%) and tracheotomy (0.8%). Two types of mechanical ventilation were used: invasive ventilation in 99.2% of patients and non-invasive ventilation (NIV) in a single patient. All patients were on controlled mode during the first few hours of their admission. For their conditioning to ventilators, 90.97% of patients (121) received sedation-analgesia based on Fentanyl combined with Hypnovel (91) and sedation alone with Hypnovel alone (19) and Thiopental in one patient. Volume-controlled ventilation mode was the most commonly used in 83.46% of cases; pressure-controlled mode was used in 16.54% of cases, or 22 patients.

The progression of these patients under artificial ventilation was marked by the occurrence of the following events:

- Improvement in hemodynamic status in 71.42% of patients (95);
- Thirty-one patients were weaned off mechanical ventilation and transferred to other wards.
- Twenty-two patients experienced weaning failure. The causes are presented in Table IV.

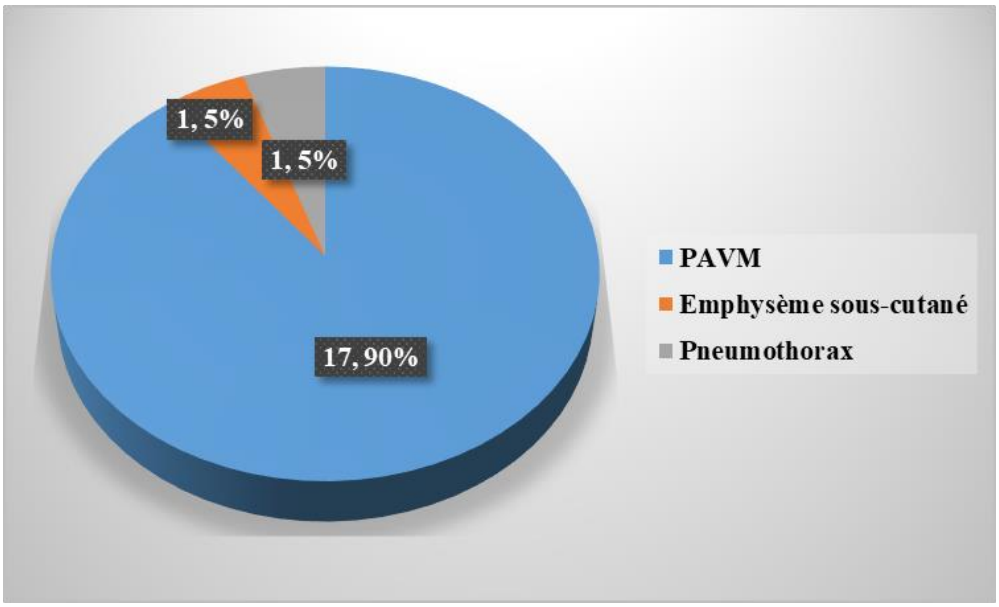
Table IV: Distribution of patients according to causes of weaning failure

Probable cause of weaning failure	**Frequency**	**Pourcentage**
Neurological deterioration	**9**	**41,0**
Respiratory failure	5	22,7
VAS obstruction	1	4,5
Abundant secretion/bronchial congestion	7	31,8
Total	**22**	**100,0**

Neurological deterioration was the cause of weaning failure in 41% of cases (n=9).

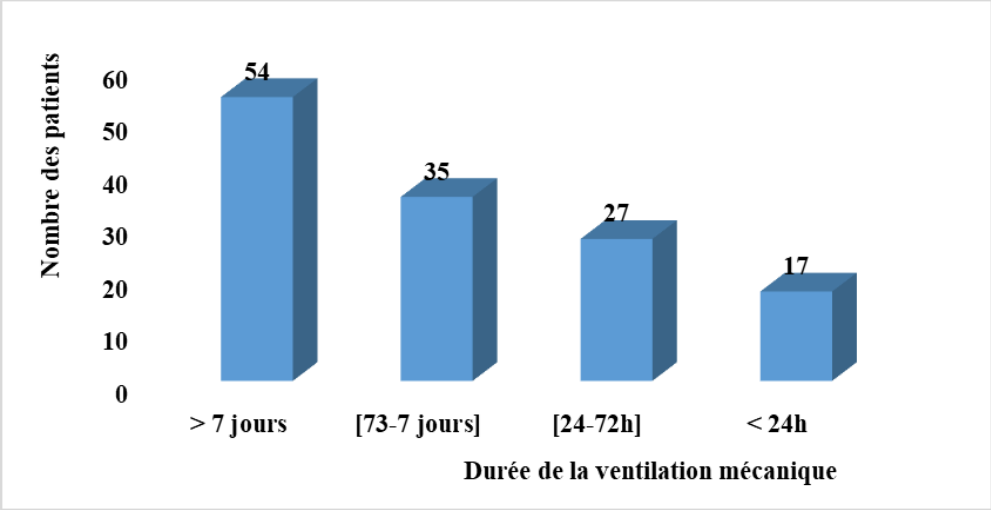
Ventilation weaning had not been initiated in 81 patients before their death. Several complications were reported. Ventilator-associated pneumonia (VAP) was the most commonly reported complication in 89.5% of cases (n=17). These are summarized in Figure 3.

Figure 3: Distribution according to the type of complication related to mechanical ventilation



The duration of artificial ventilation varied from a few hours to more than 27 days, with an average of 6±5.3 days. MV lasted more than 7 days in 40.6% of cases (n=54). Figure 4 provides more detail.

Figure 4: Distribution according to duration of mechanical ventilation



Unfortunately, we recorded 102 deaths, representing a rate of 77%.

Discussion and Comments

Socio-Demographic Aspects

Frequency:

The frequency of MV in our study is 27.19%. This result is similar to that reported by Wade et al. (Wade et al., 2011) in Senegal in 2011, which reported a frequency of 28.69%, and that found by Khatib et al. (Khatib et al., 2018) (26%) in India in 2018. This lower incidence could be explained by the fact that our center is young and therefore requests for admission from hospital services in the region are not part of practitioners' daily routine.

However, our result is significantly higher than that reported by Ampofo et al. (Osei-Ampofo et al., 2018) (8.8% in Ghana in 2018) and that reported by DurasnelL et al. (Durasnel et al., 2005) 15.8% in the Comoros in 2005. This could be related to the fact that our study setting is a third-level referral center in Niger and that it is the only intensive care unit in the interior of the country with ventilatory support capacity, even covering part of neighboring Nigeria.

Gender

The sex ratio was in favor of males at 3.29. This result is similar to that of Hamza M.B. (Hamza, 2021) (2.69) in Morocco in 2021 and that reported by Meleard et al. (Méleard et al., 2015) (2.19) in France in 2015, unlike Diop T.M. (Diop et al., 2023) in Mali in 2023, where the sex ratio favored women at 0.95. The predominance of males in our study could be explained by the fact that the main reason for admission was head trauma, to which males are more prone.

Age

The 15-60 age group is the most represented in 70.7% of cases, a result similar to that reported by Diop T.M. (Diop et al., 2023)75% in Mali in 2023 and that found by Hamza M.B. (Hamza, 2021) in Morocco in 2021, where the 15-60 age group represented 74%. The average age in our study was 40.70±19.25 years with extremes of (4 to 87 years), very similar to that reported by Wade et al. (Wade et al., 2011) 39.14±18.25 (extremes of 4 to 90 years) in Senegal in 2011 and that of Diop T.M. (Diop et al., 2023) 36.47±18.77 (ranging from 2 to 80 years) in Mali in 2023, but significantly lower than that found by Meleard et al. (Méleard et al., 2015) in France in 2015 with an average age of 67 years (ranging from 55 to 87 years) and that found by Suroux et al. (Suroux et al., 2017) in France in 2017 with an average age of 68 (ranging from 54 to 80). This could be explained by the fact that the population in Africa is predominantly young.

Clinical aspects

History

In our study, 79.7% of our patients had no history of the disease, a result similar to that found by Diop T.M. (Diop et al., 2023) (80% in Mali in 2023), but significantly higher than that reported by Hamza M.B. (Hamza, 2021) (52% in Morocco in 2021) and Wade et al. (Wade et al., 2011) (48.52% in Senegal in 2011).

This could be explained by the youth of our study population and the reason for admission, which was severe head trauma.

Hypertension was the most common history in 9% of cases, significantly lower than that found by Hamza M.B. (Hamza, 2021) (17% in Morocco in 2021) and that reported by Diop T.M. (Diop et al., 2023) (13.79% in Mali in 2023). This lower prevalence of a history of hypertension in our study could be explained by the fact that age is a risk factor for the onset of hypertension and that the study population in our context is young.

Reason for admission

Head trauma was the most common reason for admission in 32.3% of cases. This result is higher than that reported by Diop T.M. (Diop et al., 2023) 25% in Mali in 2023. This could be explained by the fact that young people constitute the working population and are therefore more exposed to head trauma.

Referring department

60.2% of our patients came from surgical emergency departments, which is significantly higher than the figure reported by Diop T.M. (Diop et al., 2023) (37.5% in Mali in 2023) and that found by Hamza M.B. (Hamza,

2021) (38% in Morocco in 2021). This could be explained by the fact that head trauma was the most common reason for admission in our study.

Glasgow Coma Scale

In our study, 64.2% of patients had a Glasgow Coma Scale score between 4 and 8 on admission. This result is similar to that reported by Hamza M.B. (Hamza, 2021), who reported that 70% of patients had a Glasgow Coma Scale score between 4 and 8. This similarity in results could be explained by the fact that impaired consciousness was the main indication for mechanical ventilation in our studies.

Use of mechanical ventilation

Indications

Patients with impaired consciousness and a GCS below 8 are at risk of gastric fluid aspiration and must be placed on artificial ventilation regardless of the underlying cause (epilepsy, stroke, meningoencephalitis, etc.) (Bougatab et al., 2012). These disorders of consciousness are the main indications for MV in our study (47.4%), followed by respiratory distress (29.3%). This result is similar to that reported by Wilcox et al. (Wilcox et al., 2016) in the United States in 2016, with a predominance of consciousness disorders (40.4%) followed by respiratory distress (18.2%), and that found by Angotti et al. (Angotti et al., 2017) in the United States in 2017, with a predominance of consciousness disorders (38.3%) followed by respiratory distress (17.1%). This contrasts with the findings reported by Khatib et al. (Khatib et al., 2018) in India in 2018, where respiratory distress was predominant (86%), followed by consciousness disorders (9%). This result could be explained by the fact that head trauma was the most common reason for admission in our study.

Type of ventilation

In practice, there are several types of mechanical ventilation. The most commonly used are mechanical ventilation with orotracheal intubation and non-invasive ventilation (NIV). We recorded a very low rate of NIV use in our study (1%), unlike in the United States, where Urgulu et al. (Ugurlu et al., 2016) found a frequency of 41% in 2016, 23% in France by Démoule et al. (Demoule et al., 2006) in 2006, 15% in Australia by Funk et al. (Funk et al., 2010) in 2010. The use of NIV increased from 16% in 1997 to 24% in 2002 in all intensive care patients requiring respiratory support, while in 2016, a study in Massachusetts found a 41% frequency of NIV use as first-line treatment in patients with acute respiratory failure [15, 16]. This difference in results in our study could be explained by the lack of adequate equipment for this ventilation method.

Type of ventilation

IOT was the main method used for MV in 98.5% of cases. This result is similar to that reported by DIOP T.M. (Diop et al., 2023) 92% in Mali in 2023. These results could be explained by the fact that invasive ventilation is the most commonly used method in our context and that it is provided via an endotracheal tube.

Ventilation mode

Ventilation modes can be classified as volumetric mode and barometric mode. Volumetric mode is by far the most commonly used mode, both for historical reasons and because it allows reliable monitoring of ventilation and, in particular, tidal volume (Viale et al., 2008). Volumetric mode was the most commonly used in our study (84%), a result similar to that reported by Diop T.M. (Diop et al., 2023) (82% in Mali in 2023) and that found by Esteban et al. (Esteban et al., 1994) (81% in Spain in 1994). However, it is higher than that reported by Ayé et al. (Yd & Ser, 2024) (75.3%) in Ivory Coast in 2024. This could be explained by the fact that patients are admitted in an altered general condition and do not have sufficient autonomous respiratory capacity to trigger the ventilator. The advantages, especially in controlled mode, of this type of ventilation are that it ensures the patient receives an adequate volume per minute. It is particularly suitable for patients at the start of ventilation, when they are under sedation and analgesia.

The ventilation mode on day 0 was dominated by volume-controlled ventilation (VCV) in 75.2% of patients, followed by spontaneous ventilation with inspiratory assistance (SV-IA) in 16.5% of patients and intermittent controlled assisted ventilation (ICA) in 8.3% of cases. This result is similar to that found by Diop T.M. (Diop et al., 2023), which was 74% VCV, 15% VS-AI, and 8% VACI. However, it differs from that reported by Esteban et al. (Esteban et al., 1994) in Spain in 1994, which was 55% VCV, 26% VACI, and 8% PAC. This could be explained by the fact that the method of ventilatory weaning differs depending on the department.

Sedation-analgesia

In our study, 98% of patients received sedation-analgesia consisting mainly of a combination of Hypnovel and Fentanyl. This result is similar to that found by Hamza M.B. (Hamza, 2021) (92% in Morocco in 2021). However, it is significantly higher than that reported by Kiersek et al. (Kierzek & Pourriat, 2005) (72.13% in France in 2005) and that found by Ayé et al. (Yd & Ser, 2024) (75.3% in Ivory Coast in 2024). This can be explained by the fact that, upon admission, the majority of patients placed on mechanical ventilation, with severe neurological and/or respiratory

conditions, received sedation or even neurosedation, as indicated, in order to improve the various treatments.

Progress of patients on mechanical ventilation

Weaning test

Weaning from MV can be defined as "the definitive discontinuation of mechanical ventilation, made possible by the resumption of effective spontaneous ventilation, most often allowing extubation" (Bollaert, 2001).

Choosing the ideal moment is crucial: weaning too early exposes patients to the risk of extubation failure, while weaning too late exposes them to the complications of mechanical ventilation and prolonged decubitus. It is generally accepted that the average duration of weaning is approximately 40% of the total duration of mechanical ventilation (MV) [19,23].

In our study, weaning from mechanical ventilation was successful in 58% of cases. This result is similar to that found by Diop T.M. (Diop et al., 2023) (61.1% in Mali in 2023) but higher than that reported by Hamza M.B. (Hamza, 2021) (21% in Morocco in 2021). The high rate of trauma patients admitted to our intensive care unit had a definite impact on the success rate of ventilator weaning. Indeed, trauma management is well codified in intensive care.

Causes of weaning failure

Consciousness disorders were the main cause of weaning failure (41%), followed by bronchial hypersecretions (31.8%). This result is similar to that reported by Saiphoklang et al. (Saiphoklang & Auttajaroon, 2018) in Thailand in 2018, with a predominance of consciousness disorders (51%) followed by bronchial hypersecretions (40.3%). Unlike Diop T.M. (Diop et al., 2023) in Mali in 2023, where airway obstruction and impaired consciousness were the main causes of weaning failure (29.4% each).

Duration of mechanical ventilation

In our study, 40.6% of patients had been on mechanical ventilation for more than 7 days. This result is significantly higher than that reported by Diop T.M. (Diop et al., 2023) (19.4%) in Mali in 2023. This result could be explained by the fact that invasive ventilation was mainly used in our study.

Complications under MV

Although it has many advantages, MV can also be responsible for numerous, often very serious injuries, which vary in type and severity depending on the patient's condition and the extent of their injuries.

Complications from invasive mechanical ventilation account for one-fifth of all iatrogenic complications (Auriant et al., 2005).

Ventilator-associated pneumonia is diagnosed in patients who have been on mechanical ventilation for at least 48 hours. According to a survey conducted by the French-speaking Resuscitation Society (SRLF), 10 to 30% of patients on ventilation in intensive care develop VAP (Bertholet et al., 2010). In our study, VAP was the main complication encountered during MV (89.5%), significantly higher than that reported by Danaoui et al. (Danaoui et al., 2011) (10% in France in 2011) and that found by Wit et al. (De Wit et al., 2009) (24% in the United States in 2009). Being in a country with limited resources, our service does not effectively comply with hygiene precautions. Indeed, some single-use materials are reused after disinfection. To this we can add the poor maintenance of ventilator circuits and the suction conditions in our context, where aseptic measures are weak.

Case fatality rate

In our study, the case fatality rate under mechanical ventilation was 77%. This result is similar to that of Ayé et al. (Yd & Ser, 2024) (79% in Côte d'Ivoire in 2024). However, it is significantly higher than that reported by Bougatab et al. (Bougatab et al., 2012) (31% in Morocco in 2012) and that found by Besset et al. (Du Besset et al., 2011) (32% in France in 2011). Apart from the fact that Morocco and France have adequate technical facilities for better intensive care, we could explain this situation by the fact that the majority of patients who deteriorate in terms of ventilation, neurological or cardiac function will benefit from invasive MV in order to maximize the management of their condition. The low level of knowledge and mastery of resuscitation equipment among the majority of staff could also contribute to this high patient mortality rate.

Conclusion

Mechanical ventilation is used on an almost daily basis in the intensive care unit of the referral hospital in Maradi. Our study shows that the majority of patients were young males admitted mainly for head injuries. The main indications for mechanical ventilation remain disorders of consciousness followed by respiratory distress. Invasive ventilation remains the most commonly used method compared to non-invasive ventilation (NIV) despite its complications. The volumetric mode is used more than the barometric mode because it allows reliable monitoring of ventilation and, in particular, tidal volume (Vt). The main complication associated with mechanical ventilation remains VAP. The management of mechanical ventilation is an important procedure performed by the department's anesthesiologists and intensive care physicians to compensate for the lack of

oxygenation and reduce respiratory effort, thereby helping patients meet their metabolic needs. Invasive mechanical ventilation is a life-saving intervention for many patients with respiratory failure. However, this study allows us to highlight the impact of MV in our intensive care unit, particularly its high mortality rate, hence the need to understand how ventilators work in order to better adapt them to our patients who require MV. Paying particular attention to ventilator settings and carefully adjusting parameters helps to provide high-quality critical care. Therefore, training intensive care staff on ventilator settings, acquiring suitable resuscitation equipment, and performing regular maintenance will enable us to provide high-quality care.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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