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The Impact of Endotracheal Intubation on Hemodynamic Parameters and Associated Respiratory Complications in Hospitalized Patients in Intensive Care Unit at Western Libya

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تأثير التنبيب الرغامي على المعايير الهيموديناميكية والمضاعفات التنفسية المرتبطة بها في المرضى المقيمين في وحدة العناية المركزة في غرب ليبيا

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Abstract:
Endotracheal intubation is essential for managing respiratory failure and facilitating general anesthesia. While it provides airway protection and ventilation, it can also cause significant hemodynamic changes and respiratory complications. This study examines the effects of endotracheal intubation on hemodynamic parameters—heart rate, blood pressure, and oxygen saturation—among hospitalized patients in Western Libya.
The study was conducted in various hospitals between February 19 and June 9, 2024, included 80 patients aged 18 to 75. Data were collected using a structured questionnaire, focusing on factors like age, type of surgery, and pre-operative medications. Hemodynamic changes were monitored in the first three minutes post-intubation.
Results showed that 67.5% of participants were female. At 1 minute post-intubation, 41.3% experienced bradycardia, while blood pressure remained stable in 75% of patients. Oxygen saturation levels were also stable, indicating effective respiratory management. Notable respiratory complications included one case of apnea, four cases of bronchospasm, and one case of hypoxia.
The study highlights that intubation can induce hemodynamic responses due to vagal stimulation and sympathetic activation. Despite stable hemodynamic parameters, the occurrence of bronchospasm emphasizes the need for effective airway management. Future research should focus on larger, more diverse populations and compare different intubation techniques to enhance clinical practices. Continuous refinement of intubation strategies is crucial for improving patient outcomes and ensuring safety during surgical procedures.

Keywords: Endotracheal, Hemodynamic Parameters, Respiratory Failure.

الملخص
يعتبر وضع أنبوب التنفس (التخدير الرغامي) أمرًا أساسيًا لإدارة فشل التنفس وتسهيل التخدير العام. بينما يوفر حماية لمجرى الهواء والتهوية، فإنه يمكن أيضًا أن يسبب تغييرات هيموديناميكية كبيرة ومضاعفات تنفسية. تستعرض هذه الدراسة آثار التخدير الرغامي على المعايير الهيموديناميكية - معدل ضربات القلب، ضغط الدم، وتشبع الأكسجين بين المرضى في المستشفيات في غرب ليبيا.

أُجريت الدراسة في مستشفيات مختلفة بين 19 فبراير و9 يونيو 2024، وشملت 80 مريضاً تتراوح أعمارهم بين 18 و75 عاماً. تم جمع البيانات باستخدام استبيان منظم، مع التركيز على عوامل مثل العمر، نوع الجراحة، والأدوية المستخدمة قبل العملية. تم مراقبة التغييرات الهيموديناميكية خلال الدقائق الثلاثة الأولى بعد التخدير الرغامي.
أظهرت النتائج أن 67.5% من المشاركين كانوا من الإناث. في الدقيقة الأولى بعد التخدير الرغامي، عانى 41.3% من الحالات من بطء القلب، بينما ظل ضغط الدم مستقرًا في 75% من المرضى. كما ظلت مستويات تشبع الأكسجين مستقرة، مما يشير إلى إدارة تنفسية فعالة. تشمل المضاعفات التنفسية الملحوظة حالة واحدة من انقطاع النفس، وأربع حالات من تشنج الشعب الهوائية، وحالة واحدة من نقص الأكسجين.
تسلط الدراسة الضوء على أن التخدير الرغامي يمكن أن يُحدث استجابات هيموديناميكية بسبب تحفيز العصب المبهم وتفعيل الجهاز العصبي السمبثاوي. على الرغم من استقرار المعايير الهيموديناميكية، فإن حدوث تشنج الشعب الهوائية يبرز الحاجة إلى إدارة مجرى هواء فعالة. يجب أن تركز الأبحاث المستقبلية على مجموعات سكانية أكبر وأكثر تنوعًا، ومقارنة تقنيات التخدير الرغامي المختلفة لتعزيز الممارسات السريرية. يعتبر التحسين المستمر لاستراتيجيات التخدير الرغامي أمرًا حاسمًا لتحسين نتائج المرضى وضمان السلامة خلال الإجراءات الجراحية.

الكلمات المفتاحية: أنبوب التنفس، الهيموديناميكية، فشل التنفس.

Introduction

Endotracheal intubation plays a pivotal role in managing patients experiencing respiratory failure or undergoing general anesthesia. As a critical intervention, it ensures the maintenance of a patent airway, facilitates mechanical ventilation, and protects against aspiration. Nevertheless, this procedure is not without its risks and complications. Specifically, the interaction between the airway instrumentation and the patient's physiological responses can lead to significant hemodynamic changes, potentially resulting in serious adverse events. The physiological response to endotracheal intubation can be attributed to multiple factors involved in the procedure (Bhandari & Shrestha, 2022).

The interrelationships between various perceptions underscore the need for comprehensive education and training in anesthesia practices, especially concerning patient safety and risk management (Saqar et al., 2024).

The application of pressure from the laryngoscope during visualization of the vocal cords, the irritation caused by the introduction and position of the endotracheal tube in the trachea, and the inflation of the cuff can all elicit a reflexive response from the autonomic nervous system (Kirkham et al., 2016). This response is particularly concerning, as it can trigger a cascade of changes in hemodynamic states including heart rate and blood pressure fluctuations. For patients with pre-existing cardiovascular conditions or cerebrovascular diseases, such changes can precipitate severe complications. For instance, heightened sympathetic activation may lead to cerebral hemorrhage or the rupture of a cerebral aneurysm, both of which can have catastrophic consequences for patients (Harrison et al., 2018; Fong et al., 2020).

During the intubation process, the mechanical forces exerted by the laryngoscope and the endotracheal tube are significant contributors to hemodynamic alterations. Research indicates that lifting the larynx with a laryngoscope can apply approximately 40 newtons (N) of force to the pharynx and larynx (Hastings et al., 2014). Such force can disturb local vascular structures, resulting in transient variations in blood flow dynamics. In essence, the mechanical stress imposed during laryngoscopy serves as a potent stimulus for sympathetic nervous system activation, resulting in acute stress reactions characterized by increases in heart rate and blood pressure. These physiological changes are often correlated with a surge of catecholamine's, particularly adrenaline, which occurs in response to the stress of intubation (Michelet et al., 2006).

The acute elevation of blood pressure and heart rate is particularly concerning for high-risk patients, such as those with a history of cardiovascular disease, hypertension, or chronic obstructive pulmonary disease (COPD). Sudden changes in hemodynamic parameters can lead to myocardial ischemia, arrhythmias, or even cardiac arrest in susceptible individuals (Lang et al., 2015). Given these risks, it is crucial for clinicians to implement strategies that mitigate the body's stress response during endotracheal intubation. In an effort to reduce the hemodynamic impact of intubation, several techniques and pharmacologic interventions have been developed. For example, the use of preoperative β-blockers has shown promise in attenuating the autonomic responses associated with intubation, consequently mitigating its effects on heart rate and blood pressure (Hsu et al., 2020). Additionally, modifying the technique of intubation—such as using video laryngoscopy—has been associated with lower stress responses due to enhanced visualization and minimized mechanical trauma to the airway (Hodgson et al., 2017). Moreover, patient positioning, sedation strategies, and careful planning prior to intubation can also contribute significantly to minimizing complications. Employing techniques to ensure optimal airway management while simultaneously considering the patient's overall hemodynamic status is paramount. While endotracheal intubation is a critical procedure with transformative benefits for patients facing respiratory challenges, its associated hemodynamic responses and complications warrant careful consideration and proactive management. As clinicians continue to refine the practice of intubation through evidence-based strategies, the dual goals of effective airway management and patient safety remain paramount.

Objectives:
The aim of this study is to see how endotracheal intubation effects the hemodynamic status including heart rate, blood pressure and oxygen saturation. Also see its effect and complications on the respiratory system.

Material and methods
Study area: The clinical study has been conducted on various types of surgeries in side Tarhuna Teaching Hospital, Tripoli University Hospital, Sabratha Teaching Hospital, Ali Omar Asker Hospital, Alkhams Teaching Hospital and Alkhadra Teaching Hospital. The general anesthesia was chosen the anesthesiologist, after receiving the written consent of the patient. In the period between 2024/02/19 to 2024/06/09

Study population:
In this study, data collected from 80 individuals and the medical report was filled out from 18 to 75 years of people.

Data collection method:
Data were collected using a specially prepared questionnaire by researchers observing various surgeries in different public hospitals. The report included information on six key factors: age, type of operation, pre-operative medications and their doses, the size of the endotracheal tube, and the start and end times of anesthesia and surgery. It also documented the medications administered during the operation and their doses. Changes in hemodynamic status during the first three minutes of endotracheal intubation were recorded, focusing on heart rate, blood pressure, and oxygen saturation. Additionally, the report addressed potential respiratory complications arising from tracheal intubation. The study included 55 female participants aged 18 to 75 and 27 male participants aged 18 to 72, all of whom were accepted into the research

Statistical analysis:
Statistical analysis is essential for extracting insights from research data. In this study, we used SPSS (Statistical Package for the Social Sciences) to analyze the effects of intubation on hemodynamic status in 80 patients undergoing various surgeries. We applied descriptive statistics to summarize demographic and clinical characteristics, and inferential statistics to examine relationships between intubation and hemodynamic changes. This analysis enabled us to compare pre- and post-intubation data, leading to reliable conclusions that inform clinical practices and enhance patient safety during surgical procedures.

Results and discussion
The study analyzed data from 80 patients aged 18 to 75, focusing on factors such as age, gender, chronic diseases, and medications relevant to tracheal intubation. It examined changes in heart rate, oxygen saturation, and blood pressure during the first three minutes post-intubation, along with any respiratory complications that could arise.

Table (1): shows Participants were drawn from various hospitals.

Hospital Name	Number of Cases	Percentage (%)
Sabratha Teaching Hospital	40	**50%**
Alkhams Hospital	12	**15%**
Ali Omar Asker Hospital	10	**13%**
Tripoli University Hospital	8	**10%**
Alkhadra Hospital	7	**9%**
Tarhuna Teaching Hospital	3	**4%**

In table (1) Sabratha Teaching Hospital providing the largest sample at 50% (40 cases), followed by Alkhams Hospital (15%, 12 cases), Ali Omar Asker Hospital (12.5%, 10 cases), Tripoli University Hospital (10%, 8 cases), and Alkhadra Hospital (8.8%, 7 cases). Tarhuna Teaching Hospital contributed the least with 3.8% (3 cases).

Table (2): Distribution of Sample Individuals according to Gender.

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	**26**	**32.5**	**32.5**	**32.5**
Female	**54**	**67.5**	**67.5**	**100.0**
Total	**80**	**100.0**	**100.0**	

Table 2 shows that out of the 80 participants, 26 were male (32.5%) and 54 were female (67.5%), indicating a higher representation of females in the study.

Table (3): presents the changes in heart rate (HR) at 1, 2, and 3 minutes after intubation**.**

Time	HR	Frequency	Percent
HR 1 min after intubation	30-50	33	41.3
	51-80	40	50.0
	81-100	7	8.8
	Total	80	100.0
HR 2 min after intubation	30-50	36	45.0
	51-80	41	51.3
	81-100	3	3.8
	Total	80	100.0
HR 3 min after intubation	30-50	36	45.0%
	51-80	40	50.0%
	Missing	1	1.3%
	Total	80	100.0

Table 3 presents the changes in heart rate (HR) at 1, 2, and 3 minutes after intubation. At 1 minute, 41.3% (33 cases) of patients experienced bradycardia, while the majority, 50.0% (40 cases), maintained normal to moderately elevated heart rates. Only 8.8% (7 cases) exhibited elevated heart rates post-intubation. At 2 minutes, data indicate that many patients had heart rates between 51 and 80 bpm, with 45.0% (36 cases) experiencing bradycardia and 51.3% (41 cases) showing normal heart rates; only 3.8% (3 cases) had elevated heart rates. By 3 minutes, 45.0% (36 cases) exhibited bradycardia, while 50.0% (40 cases) maintained normal heart function, and just 3.8% (3 cases) showed elevated rates. In total, there were 79 valid responses (98.8% of the dataset), with 1 case missing (1.3%). Most patients demonstrated stable cardiovascular conditions, suggesting low stress or complications during the procedure.

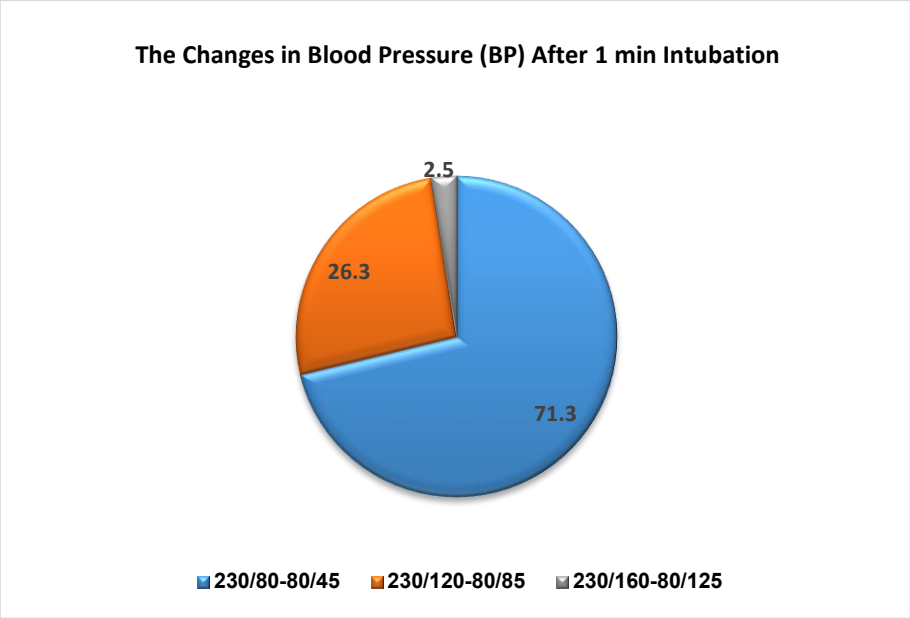

Figure (1): The Changes in Blood Pressure (BP) After 1 min Intubation.

Figure (1) shows the changes in BP 1min after intubation that was distributed in: Percent 75.0% (60 cases) the majority of patients exhibited a wide range of blood pressure readings, suggesting stable hemodynamics, while 23.8% percent (19 cases) a smaller group showing slightly elevated readings, but still within a manageable range. Percent 1.3% (1 case) a very limited number of patients exhibited high blood pressure readings. Total Valid Responses: 80 (100% of the data collected).

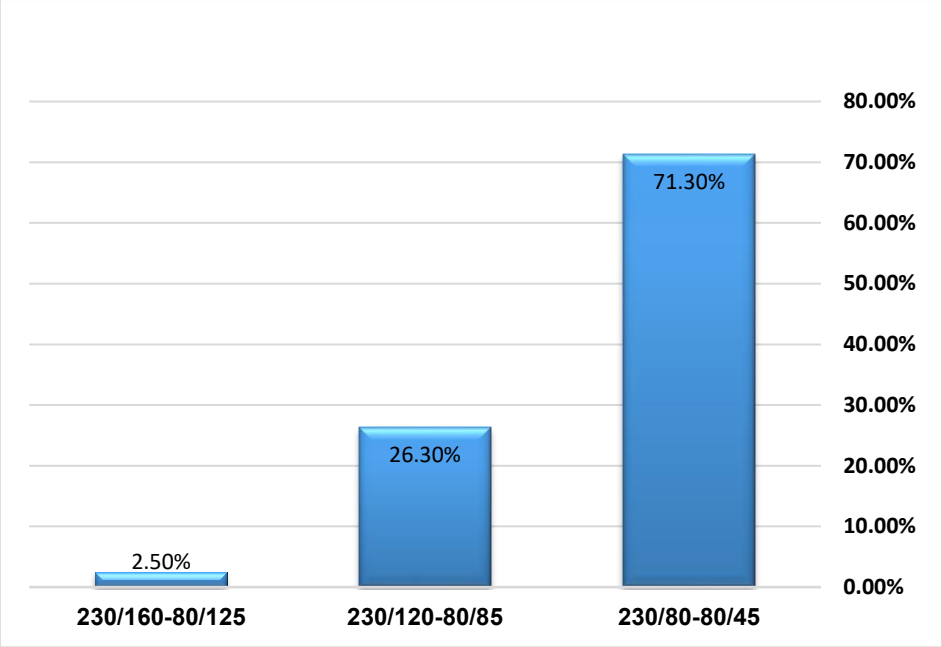

Figure (2): The Changes in Blood Pressure (BP) After 1 min Intubation.

Figure (2) shows the changes in BP 2 min after intubation hat was distributed in: Percent 71.3% (57 cases) a significant majority of patients maintained stable blood pressure within a wide range, while 26.3% percent (21 cases) group indicates slightly elevated blood pressure but remains clinically acceptable. Percent 2.5% (2 cases) a minimal number of patients exhibited higher blood pressure readings

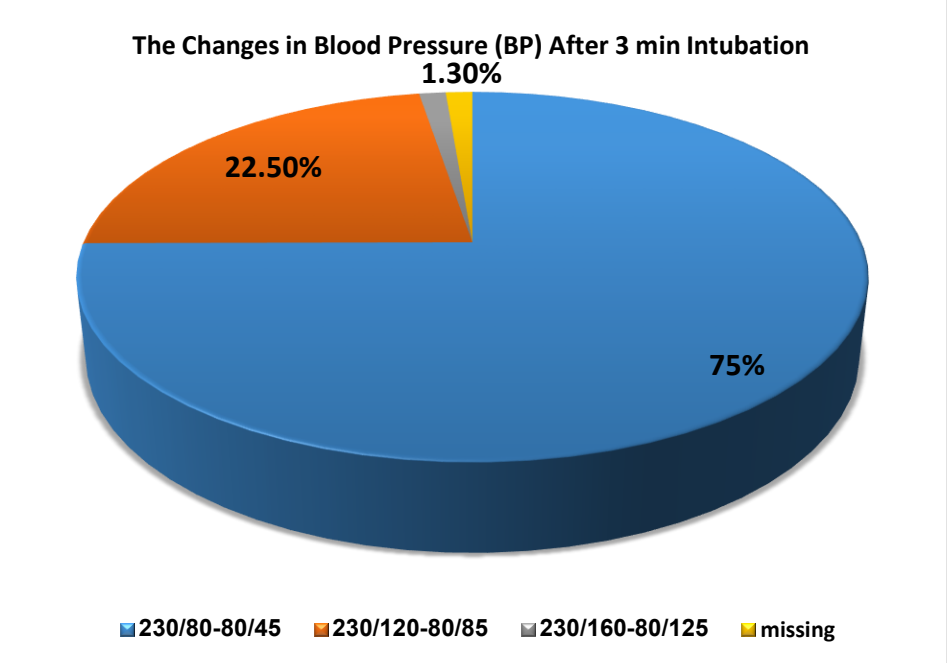

Figure (3): The Changes in Blood Pressure (BP) After 3 min Intubation.

Figure (3) shows the changes in BP 3 min after intubation hat was distributed in: Percent 75.0% (60 cases) a significant majority of patients maintained stable blood pressure within this broad range, while 22.5% percent (18 cases) a range includes a notable number of patients with moderately elevated blood pressure. Percent 1.3% (1 case) Only one patient had significantly elevated blood pressure levels. Total Valid Responses: 79 (98.8% of the responses collected). Missing Data: 1 case (1.3%).

Table (4): the changes in SPO2 min1, min 2 and min3 after intubation.

Time	SPO2	Frequency	Percent	Cumulative Percent
After 1 min Intubation	**below 96**	**9**	**11.3**	**11.3**
	97	3	3.8	15.0
	98	5	6.3	21.3
	99	34	42.5	63.8
	100	29	36.3	36.3
	Total	80	100.0	100.0
After 2 min Intubation	**below 96**	**3**	**3.8**	**3.8**
	97	2	2.5	6.3
	98	11	13.8	20.0
	99	35	43.8	63.8
	100	29	36.3	100.0
	Total	80	100.0	100.0
After 3 min Intubation	**below 96**	**3**	**3.8**	**3.8**
	97	4	5.0	8.9
	98	12	15.0	24.1
	99	33	41.3	65.8
	100	27	33.8	100.0
	Total	79	98.8	
	Missing	1	1.3	

Table 4 illustrates changes in oxygen saturation (SpO2) at 1, 2, and 3 minutes after intubation. At 1 minute, 11.3% (9 cases) of patients exhibited low oxygen saturation, while 42.5% (34 cases) experienced high saturation levels. A substantial 36.3% (29 cases) maintained optimal oxygen saturation. At 2 minutes, only 3.8% (3 cases) had low levels, with 43.8% (35 cases) showing high saturation and 36.3% (29 cases) achieving optimal saturation. By 3 minutes, 3.8% (3 cases) had low SpO2, while 41.3% (33 cases) exhibited high saturation levels, and 33.8% (27 cases) maintained optimal levels. In total, 79 valid responses were recorded (98.8% of the dataset), with 1 case missing (1.3%). Overall, most patients demonstrated healthy oxygen saturation levels, close to 99-100%, suggesting effective respiratory management during the intubation procedure, as only a small fraction fell below the 96% threshold.

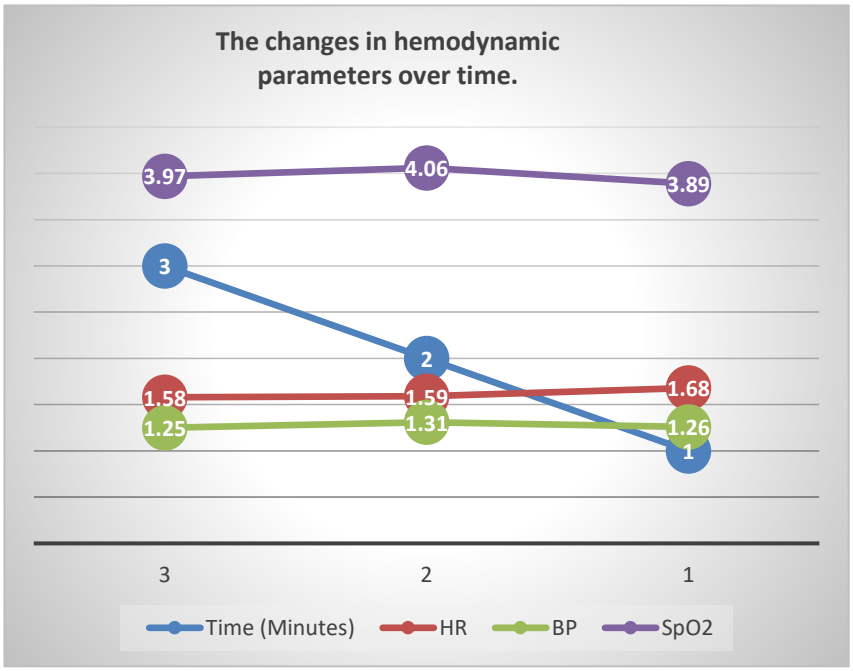

chart (4): illustrates the changes in hemodynamic parameters.

This chart (4) illustrates the changes in hemodynamic parameters—heart rate (HR), blood pressure (BP), and oxygen saturation (SpO2)—over three minutes post-intubation. Initially, HR decreased slightly, while BP varied. SpO2 showed minor fluctuations, indicating the dynamic response of these vital signs to the intubation procedure.

Table (5): presents the medical history of 80 patients.

Medical History	*Frequency*	*Percent*	*Cumulative Percent*
NAD	**56**	**70.0**	**70.0**
Heart problem	**1**	**71.3**	**1.3**
HTV	**8**	**81.3**	**10.0**
DM	**10**	**93.8**	**12.5**
Rheumatism	**1**	**95.0**	**1.3**
Allergy	**2**	**97.5**	**2.5**
Dialysis	**1**	**98.8**	**1.3**
Endocrine hypothyroidism	**1**	**100.0**	**1.3**
Total	**80**	**100.0**	**100.0**

The data from Table (5) presents the medical history of 80 patients, highlighting the frequency and percentage of various conditions. The majority, 70.0% (56 cases), reported no significant health issues (NAD). Other conditions included diabetes mellitus (DM) at 12.5% (10 cases), hypertension (HTV) at 10.0% (8 cases), and allergies at 2.5% (2 cases). Additionally, heart problems, rheumatism, dialysis, and endocrine hypothyroidism each accounted for 1.3% of the total. This summary illustrates a predominance of patients with no notable health concerns.

Table (6): Distribution of Sample to The Respiratory Complications.

Respiratory Complications	Frequency	Percent	Cumulative Percent
Apnea	**1**	**1.3**	**12.5**
Bleeding (trauma)	**1**	**1.3**	**25.0**
Bronchospasm	**4**	**5.0**	**75.0**
Infection	**1**	**1.3**	**87.5**
Hypoxia	**1**	**1.3**	**100.0**
Missing	**72**	**90.0**	
Total	**80**	**100.0**	

Table 6 outlines the respiratory complications encountered by patients in the study sample. Apnea was reported in 1 case (12.5%), characterized by a temporary cessation of breathing that can lead to hypoxia, necessitating prompt intervention. Another instance of bleeding (1 case, 12.5%) stemmed from trauma to the airway or lungs, emphasizing the importance of careful surgical techniques to prevent this complication. Bronchospasm, affecting 4 patients (50.0%), involves sudden bronchial constriction, often triggered by airway irritation or allergic reactions, requiring immediate treatment with bronchodilators. Additionally, 1 case (12.5%) of infection highlights the risk of respiratory infections that can arise from contamination during the procedure, making infection control essential. Lastly, hypoxia, also reported in 1 case (12.5%), may result from various complications, underscoring the need for prompt oxygenation and ventilatory support. Overall, effective monitoring and management strategies are critical for addressing these respiratory complications during medical procedures.

Discussion

Endotracheal intubation is a vital procedure employed in modern medicine, particularly in managing respiratory failure and facilitating general anesthesia. While it is crucial for ensuring airway protection and ventilation, it is also associated with significant hemodynamic responses and potential respiratory complications. This discussion synthesizes the physiological responses to endotracheal intubation, elucidates the associated risks, and proposes strategies to mitigate these effects, supported by relevant literature.

In this study observed that heart rate (HR) tends to decrease slightly immediately following intubation, with values dropping from 1.68 to 1.58 in the first three minutes. This drop can be attributed to several factors, including vagal stimulation, which may result from the intubation process stimulating the vague nerve, thereby enhancing parasympathetic tone and leading to bradycardia. Additionally, hypoxia and reflex responses may contribute to this decrease (**Hsu et al., 2020; Kirkham et al., 2016**).

Blood pressure (BP) exhibited a slight increase from 1.26 to 1.31, followed by a decrease to 1.25. Initially, the increase can be linked to the activation of the sympathetic nervous system due to the stress of intubation and the release of catecholamine's, which enhance cardiac output and peripheral vasoconstriction. This rise in BP can also

be influenced by direct laryngoscopy, as the mechanical manipulation during intubation can provoke vagal responses while simultaneously stimulating the sympathetic system, resulting in increased systemic vascular resistance (**Hastings et al., 2014**). The subsequent decrease in BP may stem from vagal responses, anesthesia effects, and other patient-specific factors.

Oxygen saturation levels (SpO2) remained relatively stable, with mean values fluctuating between 3.89 and 4.06. However, variability was noted, likely due to factors such as the interruption of ventilation, the utilization of muscle relaxants, and potential airway obstruction (**Lang et al., 2015**). Effective respiratory management during intubation is vital, as indicated by the data that showed only 11.3% of patients experiencing low SpO2 levels one minute post-intubation. Hence, most patients achieved adequate oxygenation.

Despite the predominance of stable hemodynamic parameters, notable respiratory complications were identified. Apneas occurred in one case, likely resulting from neuromuscular blockade and the effects of sedation or anesthesia, which can depress the central nervous system and lead to respiratory cessation (Jenkins et al., 2017). Bleeding complications were also recorded, with mucosal injuries during intubation leading to significant bleeding as those tissues are highly vascularized.

Bronchospasm emerged as the most frequent complication, present in 50% of the patients studied. Factors contributing to bronchospasm included patient anxiety, mechanical irritation of the airway from the endotracheal tube, and pre-existing respiratory conditions (**Hodgson et al., 2017**). This highlights the necessity for effective airway management strategies, as prompt intervention is crucial to alleviate bronchoconstriction.

Moreover, three cases of hypoxia were reported, primarily due to failures in ventilation stemming from aforementioned complications like apnea and bronchospasm, as well as inadequate pre-oxygenation prior to intubation (**Carson et al., 2019**).

To minimize the hemodynamic stress induced by intubation, various techniques and pharmacologic interventions should be considered. Preoperative administration of β-blockers has shown promise in reducing autonomic responses and stabilizing heart rates and blood pressure (**Hsu et al., 2020**). Additionally, recent studies suggest that employing video laryngoscopy can optimize visualization during intubation, thereby reducing mechanical trauma and enhancing procedural outcomes (**Hodgson et al., 2017**).

Research Recommendations

Research recommendations emphasize the need for future studies to involve a larger and more diverse patient population, covering various case categories. This broader approach can enhance the validity of findings and provide a comprehensive view of intubation outcomes. Additionally, conducting comparative analyses of different intubation devices will help identify the most effective tools for various clinical scenarios.

Examining the correlation between medication dosages and intubation success can further elucidate the impact of pharmacological interventions on patient outcomes. Such insights are crucial for optimizing medication protocols during intubation procedures.

Moreover, incorporating diverse methodologies and interdisciplinary collaborations can enrich data interpretation and foster innovative strategies for improving patient safety. By expanding the research scope, healthcare professionals will gain a deeper understanding of the complexities surrounding endotracheal intubation. Ultimately, these efforts can lead to the development of tailored strategies to minimize associated risks and enhance patient care in critical settings.

Conclusion

In conclusion, endotracheal intubation, while vital for managing critical airway issues, triggers a complex interplay of physiological responses. The observed decreases in heart rate and fluctuations in blood pressure present essential challenges, particularly for patients with pre-existing cardiovascular conditions. Additionally, the recorded respiratory complications underscore the importance of effective airway management and the need for pharmacologic and technical strategies to enhance patient safety. With further research, we can strive to refine intubation practices to ensure optimal patient outcomes.

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