Original Article

The Effects of Endotracheal Suctioning and Invasive Interventions on Hemodynamic Parameters and Pain Behaviors in Adult Intensive Care Patients: Observational Study

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Abstract
Background: The prevention and treatment of pain may positively influence mechanical ventilation, physiological indicators and the use of analgesic drugs, and the mortality rate. Depending on invasive procedures, intubated patients experience varying levels of pain and may have various responses to pain.
Aim: The present study aimed to define pain behaviors and hemodynamic parameters and to examine the effects of endotracheal suctioning and invasive procedures on hemodynamic parameters and pain behaviors in adult intensive care patients.
Methods: The study was conducted using a descriptive-observational design. Each patient was observed during 1 suctioning and 2 different invasive procedures (3 observations). Researchers observed each patient during one suctioning procedure and 2 invasive procedures (intra-arterial catheter insertion, nasogastric tube application, subcutaneous injection, or intravenous catheter insertion). The pain behaviors and hemodynamic parameters were evaluated 4 times in total (before the procedure, during the procedure, 5 minutes, and 15 minutes after the procedure). The observation results were recorded.
Results: Statistically significant differences were detected in hemodynamic parameters (i.e. blood pressure, pulse rate, saturation) observed before, during, and after the suctioning ($p < .05$). The sample consisted of 66 intubated patients treated at the intensive care unit. Behavioral Pain Scale scores increased during the suctioning and invasive procedures compared to pre-suctioning. Nasogastric tube insertion, intra-arterial catheter insertions, and intravenous injection applications were the most painful interventions, respectively.
Concluson: The intensive care patients must be monitored closely for pain indicators and hemodynamic changes during invasive procedures. Especially nasogastric tube insertion and injection applications must be performed carefully.

Keywords: Endotracheal suction, intensive care, procedure, pain

Introduction

Intensive care patients experience pain for reasons such as deep breathing and coughing exercises and existing diseases, invasive procedures (e.g. drainage, endotracheal tube, endotracheal suction, insertion and removal of catheters), prolonged immobility, trauma, and routine nursing interventions (e.g. dressing change, removal of the wound drain, wound care, repositioning, suctioning). Patients experience more pain in the intensive care unit than patients in other units. Gomarverdi et al. (2019) reported that critically ill patients experienced mild-to-moderate pain during various caring interventions (changing position, and respiratory physiotherapy, pain during mouthwash).

Endotracheal suction and invasive procedures cause changes in pain experience, hemodynamic parameters, and mechanical ventilator values. Unprevented or untreated pain is a source of psychological and physiological stress for intensive care patients and is among the factors that delay recovery (Azevedo-Santos, DeSantana, 2018; Young et al., 2006). Gomarverdi et al. (2019) observed moderate pain during secretion suctioning in critically ill patients. Facial expression changes were detected in 94% of patients who underwent endotracheal suction, body movements in 78%, and muscle tension in 68%. The same study found also that pain increased significantly during the procedure in 105 patients who underwent endotracheal suction (Korkutan-Efe, Dedeli-Caydam, 2020). The prevention and treatment of pain may positively influence mechanical ventilation, physiological indicators and the use of analgesic drugs, and the mortality rate (Hamdan, 2019). Depending on invasive procedures, intubated patients experience varying levels of pain and may have various responses to pain. Nurses have important roles in the assessment and interpretation of pain responses.

Aim: The purpose of the study is to examine the effects of suctioning and invasive procedures on pain behaviors and hemodynamic parameters in intubated intensive care patients.

Hypotheses

- H0(1): There is no difference between hemodynamic parameters in intubated intensive care patients before, during, and after aspiration.
- H1(1): There is a difference between hemodynamic parameters in intubated intensive care patients before, during, and after aspiration.
- H0(2): There is no difference in pain scores in intubated intensive care patients before, during, and after invasive procedures.
- H1(2): There is a difference in pain scores in intubated intensive care patients before, during, and after invasive procedures.

Method

Design

We used a descriptive observational design.

Research Setting

The present study was conducted at the anesthesia intensive care unit of a training and research hospital in Istanbul, Turkey.

Research Population and Sample

The study population included intubated patients. The research data was collected between June 2022 and September 2022. The inclusion criteria of the patients were determined as follows:

- being 18 years or older,
- being intubated,
- having stable vital signs; and
- having a score of > 5 on the Glasgow Coma Scale Score (GCS).

The exclusion of the patients:

- A total of seven patients were excluded because they did not meet the inclusion criteria.
- Out of seven patients, three patients obtained a score of ≤ 5 from GCS, two patients were hemodynamically unstable, and two patients were treated with neuromuscular agents.

Data Collection

a) Inter-rater reliability (agreement between the observers): The two observers evaluated 10 patients independently. These two observers observed each patient before, during, and 5 and 15 minutes after the procedure. They begin and stop the observations at the same time and the observers kept the independent recording confidential to avoid any bias.

The records of both observers were compared using ICC (Intraclass Correlation Coefficient) Analysis. In the current study, the inter-rater reliability coefficients ranged from 0.757 to 1.000. The coefficients indicate that inter-rater reliability coefficients showed that agreement between the observers was excellent.

b) Data collection: Each patient was observed during 1 suctioning and 2 different invasive procedures (3 observations). Researchers observed each patient during one suctioning procedure and 2 invasive procedures (intra-arterial catheter insertion, nasogastric tube application, subcutaneous injection, or intravenous catheter insertion). The pain behaviors and hemodynamic parameters were evaluated 4 times in total (before the procedure, during the procedure, 5 minutes, and 15 minutes after the procedure). Data were collected during the day and night shifts.

The observation results were recorded. The flow of the data collection is summarized in Figure 1. The observations were recorded in paper-based format.

Data Collection Tools: ***Patient Information Survey:*** The survey included questions regarding the patient's identification number, age, duration of hospitalization at the intensive care unit, and mechanical ventilator parameters (PEEP pressure, FiO_2, diagnosis, and chronic disease).

Behavioral Pain Scale: This scale is used to assess pain in patients who are sedated and critically ill. The scale was developed by Payen et al. in 2001. The scale was reported to be a valid tool for measuring the pain levels in patients who are sedated and critically ill.

The tool is an observational scale. Payen suggests that the scale is used at rest and during the noxious stimulus. There are three subscales, including Facial expression, Upper limb expression, and Compliance with the mechanical ventilator. Each subscale is scored between 1 (no response to pain) and 4 (complete response to pain). The lowest score obtained from the scale is 3 and the highest score is 12. A Behavioral Pain Scale score of > 5 indicates that the adult patient experiences pain (Payen et al., 2001).

Hemodynamic Parameters Evaluation Checklist: Checklist is used to record hemodynamic parameters during the noxious stimulus. The observers record the pulse, pulse pressure, intra-arterial blood pressure, mean blood pressure, saturation, and respiratory rate on this checklist. The checklist also was used to record the tidal volume, compliance, and P_{peak} 4 times in total (before the procedure, during the procedure, 5 minutes, and 15 minutes after the procedure). The checklist was prepared by researchers to record the patients' hemodynamic responses during 1 suctioning, and 2 different invasive procedures.

Data Analysis: The R vers. 2.15.3 program (R Core Team, 2013) was used for statistical analysis. Minimum, maximum, mean, standard deviation, median, first quartile, third quartile, frequency, and percentage were used in reporting the study data. The conformity of the quantitative data to the normal distribution was evaluated with the Shapiro-Wilk Test and graphical examinations. The Independent Groups *t*-test was used for the evaluations of the normally distributed variables between the groups, and the Dependent groups t-test was used for the intra-group evaluations. The Kruskal-Wallis test and Dunn-Bonferroni test were used for the intergroup evaluations of the non-normally distributed variables, and the Wilcoxon Signed-Ranks test was used for the intra-group evaluations. The Pearson Correlation Analysis was used to determine the level of correlation between the quantitative data and the statistical significance level was taken as $p < .05$.

Ethical Considerations: The study was approved by the Ethics Committee Approval (Date: 28.01.2022, no: 22/4). Institutional permission was obtained from the Istanbul Provincial Health Directorate and hospital administration. Patients were sedated due to intubation or medical condition so the researchers asked the relatives of patients for inclusion of patients into the research. Relatives gave written permission for the patient's participation.

Results

Patients Characteristics

A total of 66 patients were observed during three separate different invasive procedures. The mean age of the patients was 77.03 ± 12.27 years. Forty-five patients (68.2%) were treated for COVID-19 and seven patients (10.6%) for ARDS (Table 1).

Results of observations

The researchers observed 38 procedures of open suctioning and 28 procedures of closed suctioning (first/suctioning observation). During the second observation, the researchers observed 37 procedures of nasogastric tube insertion and 22 procedures of catheter insertion. In the third observation, the highest number of observations were made during subcutaneous injection (80.3%) and peripheral catheter insertion (10.6%), respectively. Researchers observed a total of 132 invasive procedures and 66 endotracheal suctioning (Table 1).

Findings about Hemodynamic Parameters and Pain Behaviors Observed During Endotracheal Suctioning

Statistically significant differences were detected in hemodynamic parameters (i.e. systolic and diastolic blood pressure values, mean blood pressure, pulse rate, saturation, respiratory rate) observed before, during, and after the suctioning ($p < .05$). The value of all hemodynamic parameters during the suctioning increased (except for saturation) compared to pre-suctioning values. The value of saturation during the suctioning decreased compared to pre-suctioning values ($p < .05$). The tests did not reveal statistically significant differences in terms of pulse pressure during the suctioning compared to pre-suctioning values ($p > .05$). Increased hemodynamic parameters at the 5th and 15th minutes after the suctioning returned to pre-suctioning values (Table 2).

Analyses showed differences in terms of tidal volume, compliance, and P_{peak} observed before, during, and after the suctioning in intensive care patients ($p < .05$). The tests did not reveal statistically significant differences in terms of tidal volume during the suctioning compared to pre-suctioning values ($p > .05$). The tidal volume increased at the 5th and 15th minutes after the suctioning procedure compared pre-procedure values.

The tests revealed statistically significant differences in terms of P_{peak} values during the suctioning compared to pre-suctioning values ($p < .05$). The P_{peak} values decreased at the 5th and 15th minutes after the suctioning compared to pre-suctioning values (Table 2).

The tests did not reveal statistically significant differences in terms of lung compliance during the suctioning compared to pre-suctioning values ($p > .05$). The lung compliance values decreased at the 5th minute following the open suctioning compared to pre-procedure values (Table 2). Analyses did not show differences in terms of lung compliance at the 15th minute after the suctioning compared to pre-suctioning values ($p < .05$).

Comparisons revealed statistically significant differences between the Behavioral Pain Scale scores during suctioning when compared to pre-suctioning scores ($p < .05$). The Behavioral Pain Scale scores increased during the suctioning compared to pre-suctioning. Behavioral Pain Scale scores returned to pre-procedural values during the 5th and 15th minutes ($p < .05$) (Table 3). No statistically significant difference was found between the types of suctioning in terms of Behavioral Pain Scale total scores obtained before, during, and after suctioning ($p > .05$) (Table 3).

Findings about Hemodynamic Parameters and Pain Behaviors Observed During Invasive Procedures

Statistically significant differences were detected in hemodynamic parameters (ie. systolic and diastolic blood pressure values, mean blood pressure, pulse, pulse pressure, respiratory rate) observed before, during, and after invasive procedures ($p < .05$). Analyses showed that statically differences in terms Comparisons revealed that values of hemodynamic parameters increased during nasogastric tube insertion and intra-arterial catheter insertions pre-procedure scores, respectively.

The hemodynamic parameters (ie. blood pressure values, pulse, pulse pressure, respiratory rate) returned to pre-procedure values at the 15th minute after invasive interventions. The value of saturation during the nasogastric tube insertion decreased compared to pre-pre-procedure values ($p < .05$).

The tests did not reveal statistically significant differences in terms of lung compliance and tidal volume during the invasive interventions compared to pre-procedure values ($p > .05$). The value of P_{peak} during the nasogastric tube insertion *was observed to* increase compared to pre-procedure values ($p < .05$).

Comparisons revealed statistically significant differences between the Behavioral Pain Scale scores during invasive procedures when compared to pre-invasive procedures scores ($p < .05$). The Behavioral Pain Scale scores increased during all invasive procedures compared to pre-invasive procedures. Behavioral Pain Scale scores returned to pre-procedural values compared to values following invasive procedures at the 5th and 15th minutes ($p < .05$) (Table 5).

Statistically significant differences were found between the types of invasive procedures in terms of Behavioral Pain Scale total scores obtained during, and after procedures at the 5th and 15th minutes ($p < .05$) (Table 5).

Nasogastric tube insertion, intra-arterial catheter insertions, and intravenous injection applications were the most painful interventions, respectively (Table 5). Behavioral Pain Scale scores returned to pre-procedural values compared to values following invasive procedures at the 15th minute ($p < .05$) (except for intra-venous catheter insertions, $p = 0,025$) (Table 5).

Table 1. Descriptive findings of intensive care unit patients (n = 66).

Variables	Mean ± SD	Min-Max (Median)
Age (years)	77.03 ± 12.27	39-94 (80.5)
The duration to stay in the intensive care unit (days)	7.59 ± 7.58	1-35 (5)
The duration of mechanic ventilation (days)	6.06 ± 6.58	1-35 (3)
	Number (n)	**Number Percent (%)**
Diagnosis		
COVID-19	45	68.2
Acute Respiratory Distress Syndrome (ARDS)	7	10.6
Lung Cancer	2	3.0
Chronic Renal Failure	2	3.0
Multiple Organ Failure	2	3.0
Sepsis	2	3.0
Other	6	9.0
Observation 1: Endotracheal Suction (n = 66)		
Open Suctioning	38	57.6
Closed Suctioning	28	42.4
Observation 2: Invasive Procedures (n = 66)		
Arterial catheter insertion	4	6.1
Peripheral catheter insertion	22	33.3
Nasogastric tube insertion	37	56.1
Subcutaneous injection	3	4.5
Observation 3: Invasive Procedures (n = 66)		
Arterial catheter insertion	1	1.5
Peripheral catheter insertion	7	10.6
Nasogastric tube insertion	5	7.6
Subcutaneous injection	53	80.3
Observations (2 and 3): Invasive Procedures (n = 132)		
Arterial catheter insertion	5	3.8
Peripheral catheter insertion	29	22.0
Nasogastric tube insertion	42	31.8
Subcutaneous injection	56	42.4

Table 2. Comparison of mean blood pressure, saturation, and p_{peak} values by type of suction (n = 66).

	Mean blood pressure				Saturation				P_{peak}			
	Open Suctioning	**Closed Suctioning**			**Open Suctioning**	**Closed Suctioning**			**Open Suctioning**	**Closed Suctioning**		
	Observation: 38	**Observation: 28**	**[a]Test**	**p-values**	**Observation: 38**	**Observation: 28**	**[a]Test**	**p-values**	**Observation: 38**	**Observation: 28**	**[a]Test**	**p-values**
	Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD		
Before the procedure (BP)	77.71 ± 13.52	87 ± 16.41			95.47 ± 3.05	95.96 ± 3.49	-0.608	0.546	23.05 ± 6.64	22.93 ± 4.32	0.086	0.932
During the procedure (DP)	83.37 ± 13.81	92.21 ± 15.56	-2.518	**0.014***	94.13 ± 3.51	94.39 ± 3.37	-0.304	0.762	23.00 ± 6.76	24.68 ± 5.50	-1.077	0.286
5 min after the procedure (AP5)	80.26 ± 12.2	87.75 ± 14.77	-2.437	**0.018***	96.13 ± 2.58	96.75 ± 2.55	-0.967	0.337	21.95 ± 5.50	22.11 ± 3.75	-0.133	0.895
15 min after the procedure (AP15)	79.37 ± 12.67	85.43 ± 13.92	-2.253	**0.028***	96.42 ± 2.72	96.96 ± 2.47	-0.834	0.408	21.82 ± 5.67	21.25 ± 2.98	0.525	0.602
Difference (DP-BP)	5.66 ± 7.80	5.21 ± 10.19	-1.842	0.070	-1.34 ± 1.74	-1.57 ± 1.43	0.569	0.571	-0.05 ± 2.13	1.75 ± 2.56	-3.117	**0.003***
[b]Test	-4.472	-2.707	0.200	0.842	4.744	5.834			0.152	-3.614		
p-value	**<0.001***	**0.012***			**<0.001***	**<0.001***			0.880	**0.001***		
Difference (AP5-BP)	2.55 ± 10.84	0.75 ± 6.60			0.66 ± 1.46	0.79 ± 1.5	-0.348	0.729	-1.11 ± 1.86	-0.82 ± 1.54	-0.659	0.513
[b]Test	-1.452	-0.602	0.779	0.439	-2.783	-2.773			3.669	2.821		
p-value	0.155	0.553			**0.008***	**0.010***			**0.001***	**0.009***		
Difference (AP15-BP)	1.66 ± 8.67	-1.57 ± 5.93			0.95 ± 1.47	1.00 ± 1.49	-0.143	0.887	-1.24 ± 2.28	-1.68 ± 2.28	0.778	0.440
[b]Test	-1.178	1.401	1.698	.094	-3.974	-3.550			3.339	3.899		
p-value	0.246	0.173			**<0.001***	**0.001***			**0.002***	**0.001***		

[a]Independent groups t-test [b]Dependent groups t-test *$p < 0.05$; BP: Before procedure; DP: During procedure; AP5: 5 min after the procedure**;** AP15: 15 min after the procedure

Table 3. Comparison of Behavioural Pain Scale scores by type of suction (n = 66).

Behavioural Pain Scale	Open Suctioning Number of Observations: 38 Mean ± SD	Closed Suctioning Number of Observations: 28 Mean ± SD	[a]Test	p-value
Before the procedure (BP)	4.11 ± 1.13	4.07 ± 0.94	0.129	0.898
During the procedure (DP)	7.68 ± 1.80	7.29 ± 1.63	0.924	0.359
5 min after the procedure (AP5)	4.76 ± 1.40	4.36 ± 0.99	1.378	0.173
15 min after the procedure (AP15)	3.66 ± 1.02	4.00 ± 1.09	-1.308	0.195
Difference (DP-BP)	3.58 ± 1.54	3.21 ± 1.62	0.932	0.355
[b]Test	-14.366	-10.510		
p value	**<0.001***	**<0.001***		
Difference (AP5-BP)	0.66 ± 1.05	0.29 ± 0.90	1.515	0.135
[b]Test	-3.874	-1.686		
p value	**<0.001***	0.103		
Difference (AP15-BP)	-0.45 ± 0.89	-0.07 ± 1.15	-1.495	0.140
[b]Test	3.094	0.328		
p value	**0.004***	0.745		

[a]Independent groups t test [b]Dependent groups t test *$p < 0.05$; BP: Before procedure; DP: During procedure; AP5: 5 min after the procedure; AP15: 15 min after the procedure

Table 4. Comparison of mean blood pressure values by type of invasive procedure (n = 132).

Mean Blood Pressure	Arterial Catheter Insertion Observations: 5 Median (Q1, Q3)	Peripheral Catheter Insertion Observations: 29 Median (Q1, Q3)	Nasogastric Tube Insertion Observations: 42 Median (Q1, Q3)	Subcutaneous Injection Observations: 56 Median (Q1, Q3)	[c]Test	p-values
Before the procedure (BP)	81 (81, 81)	81 (75. 89)	78.5 (73. 87)	81.5 (72. 87)	0.443	0.931
During the procedure (DP)	82 (82. 82)	83 (76. 87)	83.5 (73. 92)	80 (72. 87.5)	1.362	0.714
5 min after the procedure (AP5)	82 (82. 82)	80 (74. 90)	81 (73. 88)	80 (71. 88)	0.396	0.941
15 min after the procedure (AP15)	81 (81. 81)	82 (74. 90)	79.5 (73. 86)	78.5 (72. 86.5)	1.245	0.742

Difference (DP-BP)	1 (1. 1)	-1 (-3. 1)	3.5 (-2. 6)	-1 (-2. 1)	11.038	**0.012***
^{b}Test	-2.000	-1.408	-2.206	-0.917		
p-value	**0.046***	0.159	**0.027***	0.359		
Difference (AP5-BP)	1 (1. 1)	-1 (-2. 1)	2 (-2. 4)	0 (-2. 2)	2.978	0.395
^{b}Test	-2.000	-0.460	-1.420	-0.146		
p-value	**0.046***	0.646	0.155	0.884		
Difference (AP15-BP)	0 (0. 0)	-1 (-2. 1)	1 (-4. 3)	-1 (-3.5. 1)	2.054	0.561
^{b}Test	-1.000	-0.701	-0.266	-2.580		
p-value	0.317	0.484	0.790	**0.010***		

^{c}Kruskal-Wallis test ^{d}Wilcoxon signed-ranks test. The results are presented as median (first quartile. third quartile).
*p < 0.05; BP: Before procedure; DP: During procedure; AP5: 5 min after the procedure**;** AP15: 15 min after the procedure

Table 5. Comparison of behavioural pain scale values by type of invasive procedures (n = 132).

Behavioural Pain Scale total scores	**Arterial Catheter Insertion**	**Peripheral Catheter Insertion**	**Nasogastric Tube Insertion**	**Subcutaneous Injection**	**^{c}Test**	**p-values**
	Observations 5	**Observations: 29**	**Observations:4 2**	**Observations 56**		
	Median (Q1. Q3)	Median (Q1. Q3)	Median (Q1. Q3)	Median (Q1. Q3)		
Before the procedure (BP)	3 (3. 5)	3 (3. 4)	3.5 (3. 4)	3 (3. 4)	0.917	0.821
During procedure (DP)	6 (5. 6)	5 (4. 6)	7.5 (6. 10)	4 (3. 5)	56.722	**<0.001***
5 min after the procedure (AP5)	4 (4. 5)	4 (3. 4)	4 (4. 6)	3 (3. 4)	17.731	**<0.001***
15 min after the procedure (AP15)	4 (3. 4)	4 (3. 4)	4 (3. 4)	3 (3. 4)	3.246	0.355
Difference (DP-BP)	2 (1. 2)	2 (1. 3)	4 (3. 6)	0 (0. 1.5)	53.982	**<0.001***
^{b}Test	-2.041	-4.234	-5.393	-3.707		
p-value	**0.041***	**<0.001***	**<0.001***	**<0.001***		
Difference (AP5-BP)	1 (0. 1)	0 (0. 0)	1 (0. 1)	0 (0. 0)	29.736	**<0.001***
^{b}Test	-1.732	-1.890	-4.081	-0.632		
p-value	0.083	0.059	**<0.001***	0.527		

Difference (AP15-BP)	0 (0. 0)	0 (0. 0)	0 (0. 1)	0 (0. 0)	7.893	**0.048***
[b]Test	0.000	-2.236	-1.698	-0.816		
p-value	0.999	**0.025***	0.090	0.414		

[c]Kruskal-Wallis test, [d]Wilcoxon signed-ranks test. The results are presented as median (first quartile, third quartile). *p < 0.05, BP: Before procedure; DP: During procedure; AP5: 5 min after the procedure; AP15: 15 min after the procedure

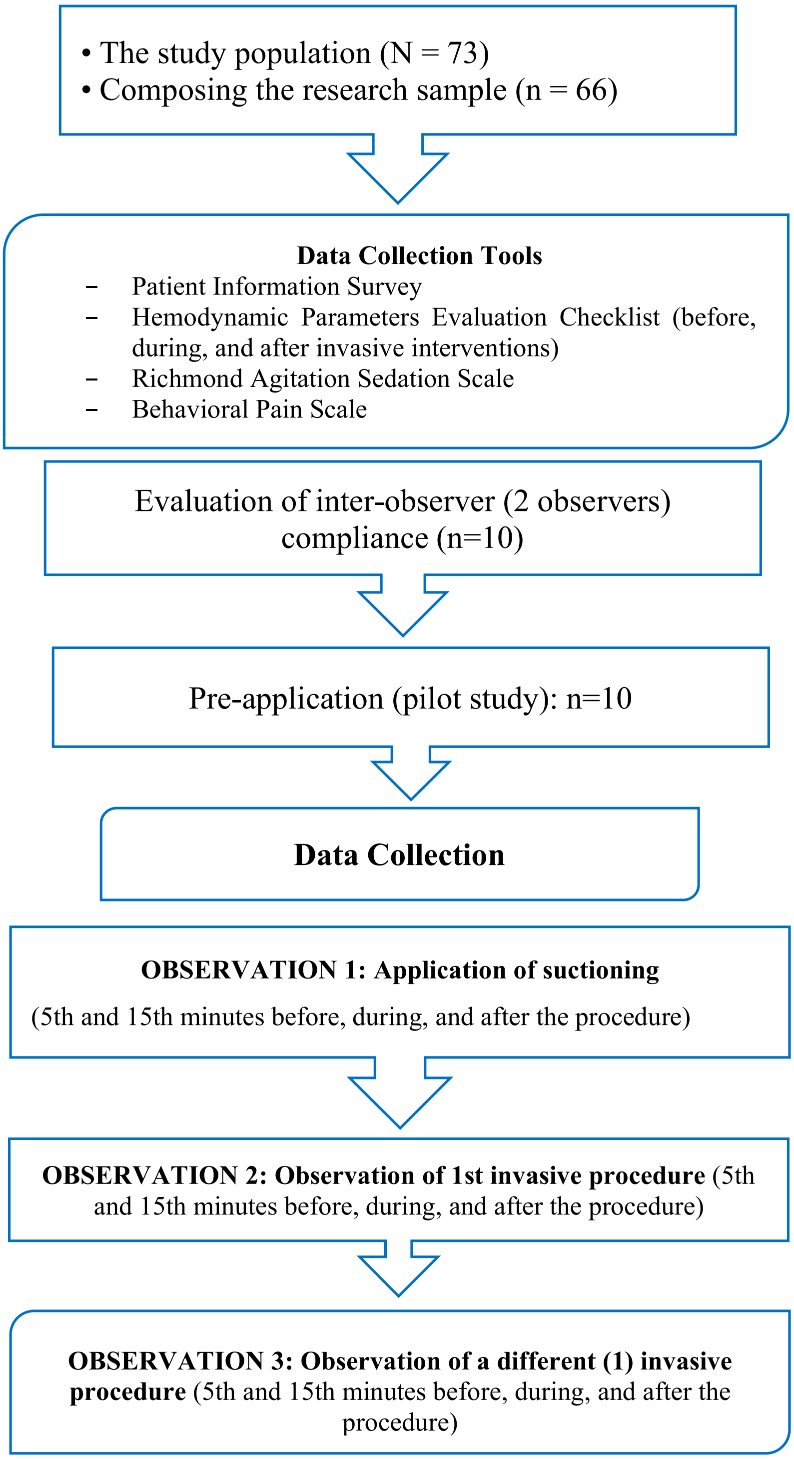

Figure 1: The data collection flow plan

Discussion

Various technological devices and treatments are used in intensive care units, which are the units where critically ill patients are treated, and vital signs and other indicators are monitored constantly. Some of the invasive procedures cause changes in hemodynamic indicators in patients and affect their vital signs. Endotracheal suction causes fear, stress, and pain in patients, and therefore, some hemodynamic changes occur with the stimulation of the sympathetic nervous system. The purpose of the study is to examine the effects of suctioning and invasive procedures on pain behaviors and hemodynamic parameters in intubated intensive care patients.

Endotracheal suction is applied to clean the secretions in the trachea, provide oxygenation, prevent obstruction in the endotracheal tube, and clear the secretions that cause atelectasis and pulmonary infections in patients dependent on mechanical ventilation. Similarly, other studies found that (n=108) the mean pain score during the endotracheal suction increased significantly (Gulsoy, Karagozoglu, 2020; Korkutan-Efe, Dedeli-Caydam, 2020). One study found that endotracheal suction is a painful intervention, the pain scores increased during endotracheal suction (pre-intervention score 4.0 ± 1.1, post-intervention score 7.3 ± 1.4) (Bayrak-Kahraman, Ozdemir, 2016).

A study conducted on 21 sedated patients found intratracheal suctioning increased the hemodynamic indicators (systolic and diastolic blood pressures) and pain scores (Jeitziner et al., 2012). The same study did not report changes in heart rate, tidal volume, and pupil size (Jeitziner et al., 2012). Ozden and Gorgulu (2015) found that the mean blood pressure value increased during suction in patients who underwent open suctioning (Ozden, Gorgulu, 2015). The mean blood pressure value increased during the procedure in patients who underwent suction (Bayrak-Kahraman, Ozdemir, 2016). Mean blood pressure was reported to increase during open and closed suction (Afshari et al., 2014). The results obtained in this study are similar to the results of other studies. The present study found that the mean blood pressure value increased during the suction in both groups that underwent open suction and closed suction and the mean blood pressure returned to pre-procedural values shortly after the procedure in those who underwent closed suction.

Seymour et al. (2009) reported that the vital volume decreased slightly during the closed suction procedure and started to increase again after the procedure. Gulsoy and Karagozoglu (2020) reported that the compliance value and the Ppeak value decreased after the suction when compared to the pre-procedure value. The current study found that the tidal volume increased after open and closed suction procedures when compared to the values observed in the pre-procedure period, and the average Ppeak value decreased after the procedure in both types of suction when compared to the values in the pre-procedure period.

Deep endotracheal suctioning was observed to cause more changes in systolic and diastolic arterial blood pressure and heart rates, and pain levels of patients compared to superficial endotracheal suctioning (Kostekli et al., 2021). The research conducted on 755 patients revealed that pain intensity scores were significantly greater during the tracheal suctioning procedure than before or after tracheal suctioning (Arroyo-Novoa et al., 2008). Khanna et al. (2018) found that critically ill mechanically ventilated patients experienced pain during tracheal suction and patient positioning. The observations revealed a significant increase in hemodynamic variables during painful procedures (Khanna et al., 2018). A study conducted on critically ill patients found that the heart rate and blood pressure during suctioning were significantly higher (Chen, Chen, 2015).

Nociceptive stimulations in critically ill sedated adult patients caused an increase in the behavioral pain scale (Payen et al., 2001). The Behavioral Pain Scale was used to evaluate the pain behaviors of the patients in this study. The results obtained in this study were similar to the literature data. The total Behavioral Pain Scale total score increased during the procedure in open and closed suction, and the high pain score decreased below the pre-procedural value at the 15th minute after the procedure in this study. In summary, both types of suction were painful applications and pain scores increased during the procedure.

Similarly, sixty-one patients were observed to experience (drain removal, deep breathing, and coughing exercises, suctioning positional change, and line removal (Siffleet et al., 2007). Khayer et al. (2020) reported higher pain in patients with open suctioning compared to those with closed suctioning. Gomarverdi et al. (2019) reported that critically ill patients experienced mild pain during changing position, and respiratory physiotherapy, mild-to-moderate pain during mouthwash, and moderate pain during secretion suctioning.

The studies found that the heart rate and systolic and diastolic blood pressure of critically ill patients were found an increase slightly following suctioning and invasive procedures (Rass et al., 2020; Siffleet et al., 2007). A study conducted on 247 mechanically ventilated patients found that the most painful procedure to be observed was repositioning. Researchers observed an increase in physiological indicators of pain during repositioning and endotracheal suctioning increased and decreased during the rest of the procedures (Ayasrah et al., 2016). Cho et al. (2021) reported that critically ill patients were observed to display various behavioral responses during procedures than before and after procedures. The same study also recorded physiological responses, and significant increases in systolic blood pressure, and diastolic blood pressure, using video cameras and bedside monitors (Cho et al., 2021).

Gagging, coughing, and breathing difficulties may occur during nasogastric tube insertion and even pneumothorax may develop. A study (Bayrak-Kahraman and Ozdemir, 2016) reported that heart rate, respiratory rate, and mean blood pressure increased during nasogastric catheterization in patients, but the saturation value decreased. Kurt and Zaybak (2022) found that heart rate, respiratory rate and mean blood pressure increased significantly during the procedure in patients with nasogastric catheters, and the saturation value decreased significantly. It was reported in the study of Ada and Yilmaz (2020) that the mean blood pressure and pulse rate increased during the procedure in patients with arterial catheters. Similarly, Gelinas et al. (2011) reported that the pulse rate increased significantly during suctioning.

Patients who are treated in the intensive care unit experience pain because of invasive and noninvasive procedures such as suction, mobilization, peripheral catheter insertion, nasogastric catheters, and injections (Carrillo-Torres et al., 2018). The pain after these interventions affects the recovery and comfort of the patients negatively and causes stress. Ineffective pain management causes an increase in care costs, length of hospital stay, and mortality rates for catheters (Ada, Yilmaz, 2020). One study reported that patients mostly reacted to invasive procedures with facial expressions (Korkutan-Efe, Dedeli-Caydam, 2020).

Although lidocaine-containing gels are used in nasogastric catheter insertion, patients still feel pain (Farrington et al., 2015). The most painful invasive procedure was the insertion of the nasogastric catheter and the same study reported that pain scores increased during arterial and intravenous catheterization procedures (Korkutan-Efe, Dedeli-Caydam, 2020). These study findings seem to be consistent with the findings of other studies. Similarly, the current study found that pain scores increased during invasive procedures. The pain scores increased following the nasogastric catheterization procedure compared to other invasive procedures.

Limitations: Most of the sample was diagnosed with COVID-19. Among observed invasive procedures, researchers could have a chance to assess the pain and hemodynamic response to arterial catheterization only 5 times. Arterial catheterization is need generally performed during an emergency and hospitalization to the intensive care unit so the researchers came across only five cases to be inserted arterial catheterization. The observers could not also observe the intubated patients during the central venous catheter insertion procedure within data collection. The intubated patients did not need this procedure during data collection or the central venous catheter was not inserted during data collection hours.

Conclusion: All hemodynamic parameters during the suctioning increased (except for saturation) compared to pre-suctioning values. The Behavioral Pain Scale scores increased during the suctioning and invasive procedures compared to pre-suctioning. The researchers observed that pain level differs in term of types of invasive procedures. Nasogastric tube insertion, intra-arterial catheter insertions, and intravenous injection applications were the most painful interventions, respectively.

Suctioning and invasive procedures cause changes in hemodynamic and mechanical ventilation parameters and pain. Therefore, these patients must be monitored closely for pain indicators and hemodynamic changes during invasive procedures. Especially nasogastric tube insertion and injection applications must be performed carefully. Invasive interventions must be performed carefully in line with evidence-based recommendations and unnecessary invasive procedures must be avoided.

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