Tracheal suctioning with versus without saline instillation

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Abstract: The primary goal of tracheal suctioning to maintain a patent airway. It is considered as one of the most common procedure in critical care areas. Normal saline instillation into an artificial airway prior to suctioning is utilised by many health practitioners. However, there are conflicting views about its safety. This study was conducted in two phases. Phase "1" aims to determine how often normal saline is used during tracheal suctioning, and determine nurses and physicians' knowledge regarding advantages and disadvantages of normal saline instillation (INS) before suctioning. Phase "2" aims to compare between the effects of suctioning with saline versus suctioning without saline on a number of physiological response parameters. This study was conducted at Causality Care Unit, and General Intensive Care Unit (ICU), Main University Hospital, University of Alexandria; including;. Ninety two nurses and 16 physicians working in the previously mentioned settings were included in the first phase of the study, while 26 adult critically ill patients were included in the second phase of the study. Two tools were used to collect required data; tool (I) tracheal suctioning questionnaire used to collect data for phase "1" and tool (II) physiological response parameters assessment sheet used to collect data for phase "2". Based on the findings of this study, it can be concluded that nurses and physicians frequently use saline before suctioning. A considerable number of them recognize the most common advantages and disadvantages to the INS. In relation to the comparison between suctioning with and without INS, this study shows that INS carries out several risks, including; significant elevation in $PaCO_2$ immediately after suctioning and reduction in oxygen tension and saturation, 5 minutes after suctioning. So, nurses and physicians have to be aware on these disadvantages of INS. In addition, alternative measures facilitating liquefying secretion and its removal have to be utilized instead of INS.
[Eman M. Zahran and Ahmed A. Abd El-Razik. Tracheal suctioning with versus without saline instillation. Journal of American Science 2011;7(8):23-32]. (ISSN: 1545-1003). http://www.americanscience.org.

Key words: instillation of normal saline, suction, physiologic response to suction.

1. Introduction:

Tracheal suctioning (TS) is an essential and frequently performed procedure for patients requiring intubation and mechanical ventilation; in which patients may need to be suctioned between 3 and 24 times or more a day [(1)]. By TS, secretions from the tracheobronchial tree are cleared, guaranteeing optimal oxygenation and avoiding accumulation of secretions, leading to tube occlusion, increased work of breathing, atelectasis, and pulmonary infections [(2)]. Critically ill patients are highly dependent on collaborative skilled health care members throughout all aspects of their care. Nurses and physicians make up the largest group of health care members and their collaboration in making decisions significantly affects patients' outcomes. Although suctioning procedure is considered as one of the nursing tasks, physicians participate in taking decisions related to its techniques and safety. One of the challenges facing the critical care nurse and the physician, when performing tracheal suctioning, is ensuring that the procedure is performed effectively without any harm. Normal saline has been widely utilized with tracheal suctioning. Clinicians use normal saline believing it lubricates the suction catheter, enhances a cough, breaks up pulmonary secretions and helps with their removal during suctioning, especially in the presence of thick secretions [(3)].

Although the INS during TS has been used for years, evidence shows that such instillation is controversial. A study finding indicates that mucus and water are like oil and water, cannot be mixed in vitro, even after vigorous shaking [(4,5)]. In addition, after instillation of saline, extra breaths are given with manual resuscitation bag (MRB) or via the ventilator, or both. In each of these circumstances, the flow of air into the lung is accelerated. If any mucus is loosen via instillation, this rapid flow of air most likely transports these secretions farther down the bronchial tree, making the secretions more difficult or impossible to retrieve with a suction catheter. The unretrieved fluid could interfere with alveolocapillary oxygen exchange, resulting in declines in oxygenation. Furthermore, INS stimulates patient to cough forcefully which may increase mean arterial pressure (MAP) and intracranial pressure [(3,6,7)]. Regarding risk of infection, it was found that INS causes dislodgment of bacterial colonies up to 5 times when normal saline is instilled, and therefore this

practice may contribute significantly to lower airway contamination [8].

On the other hand, other researchers have shown conflicting results. Two studies compared the oxygenation effects of suctioning with and without normal saline resulted in the absence of a statistical significant effects on oxygen saturation [9,10]. **Choi and Jones** [11] study suggested that manual hyperinflation associated with the instillation of 1 ml normal saline in conjunction with suction induces beneficial changes in respiratory mechanics in mechanically ventilated patients. Another study investigated the effect of INS on respiratory mechanics demonstrated no statistically significant difference in pulmonary compliance in control or intervention groups [12]. **Caruso and colleagues** [13] and **Reeve** [14] demonstrated that INS reduces the incidence of ventilator associated pneumonia in intubated patients.

Lack of researches carried out on adult patients comparing between using or not saline during suctioning, in addition to the conduction of a recent systemic review [15] reopened the debate again. The systematic review was conducted to investigate the efficacy and safety of the INS prior to suction. Its results reflect the poor quality of the available articles on examining the effect of INS prior to suction. The conclusion of this systemic review emphasized that there is little evidence of benefit but also minimal evidence of safety risks and recommended the induction of controlled trials of better quality and more clinically relevant outcomes before this technique is either accepted or rejected. Despite conflicting results on INS, this manoeuvre is being used frequently in practice, and sometimes incorporated into written guidelines. Therefore this study was conducted to determine how often normal saline is used during tracheal suctioning and nurses' knowledge regarding advantages and disadvantages of this manoeuvre. In addition, the current study will compare between the effects of suctioning with versus without saline on a number of physiological stress response parameters, including; hemodynamic parameters, oxygenation parameters, cough response, and lung mechanics.

2. Material and Methods:

Research design: This study was conducted in two phases;

Phase "1": Descriptive design.

Phase "2": Single case repeated measures quasi-experimental design, in which each patient was utilized as his/her own control. Intervention was suctioning with saline, while the control was suctioning without saline.

Aims: Phase "1":

- Determine how often normal saline is used during tracheal suctioning.
- Determine nurses and physicians' knowledge regarding advantages and disadvantages of INS before suctioning.

Phase "2":

- Compare between the effect of suctioning with saline versus suctioning without saline on physiological response parameters, including; hemodynamic parameters (hear rate "HR", systolic blood pressure "SBP", diastolic blood pressure "DBP", and Mean arterial pressure "MAP"), oxygenation parameters (pH, $PaCO_2$, PaO_2, HCO_3^-, and SaO_2), cough response, and lung mechanics (respiratory rate "RR", and dynamic compliance "Cdyn").

Research Hypotheses:

Phase "1":

- Normal saline is always used during tracheal suctioning
- Nurses and physicians cannot determine advantages and disadvantages of suctioning with INS

Phase "2":

- No statistical significant difference will be found between the effect of suctioning with saline and suctioning without saline on physiological response parameters; hemodynamic parameters (HR, SBP, DBP, and MAP), oxygenation parameters (pH, $PaCO_2$, PaO_2, HCO_3^-, and SaO_2,), cough response, and lung mechanics (RR, and Cdyn).

Settings: This study was conducted at two of the intensive care units (ICUs) of the Main university Hospital, University of Alexandria, Egypt, including; Causality Care Unit (Unit I), and General ICU (Unit III).

Subjects: for phase "1": 92 nurses and 16 physicians who were working in the previously mentioned settings and accepted to participate in the research over the period from 1/4/ 2010 to 15/4/ 2010 were included in this phase. *For phase "2":* 26 adult critically ill patients of both sexes were recruited sequentially in this study. All of patients were receiving mechanical ventilatory support via a tracheal tube either endotracheal or tracheostomy tube. Patients excluded from the study were those with refractory hypoxemia because they may not show any changes in oxygenation parameters [12] and those who are on muscle relaxants. This research

phase was conducted over the period from 30/4/ 2010 to 30/9/ 2010

Tools:

Two tools were used to collect the required data; tool (I) for phase "1" of the study, and tool (II) for phase "2".

Tool (I) tracheal suctioning questionnaire: this questionnaire was adopted from **Schwenker *et al.*, [16].** It was utilized to determine how often saline is used during suctioning by nurses and physicians and their knowledge regarding advantages and disadvantages of saline use. It consists of a number of questions on nurses/physicians' use of saline, advantages and disadvantages of its use. A number of proposed statements were listed under each question to select from and a space was left for the participants to add any other statements that are not mentioned.

Tool (II) physiological response parameters assessment sheet: It was developed by the researchers based on extensive literature review **[1,3,7,17].** It was used to collect data related to a number of physiological response parameters. It involves four parts; part (1) involves hemodynamic parameters (HR, SBP, DP, and MAP), oxygenation parameters (pH, $PaCO_2$, PaO_2, HCO_3^-, and SaO_2,), cough response, and lung mechanics (RR, and Cdyn). All these parameters used to compare between the intervention and none-intervention effects. In addition, it involves patient's related characteristics such as; demographic data, current and past medical and surgical history.

Method:

Permission was obtained from the hospital administrative authority to conduct this study after explaining it aim and the process. Tool I was adopted and tool II were developed after reviewing the related literature. Validation of the study tool (II) was assessed by presenting them to five experts from the critical care nursing field. A pilot study was carried out on 5 nurses and 5 patients to evaluate the clarity and applicability of the study tools. They were excluded from the total sample, and the necessary modifications were done.

Data collection, Phase "1":

Tool (I) was distributed to nurses and physicians working in the two ICUs by the researchers after explaining the study aims. Nurses and physicians were asked to complete and return the questionnaire to the nursing office within two days.

Study intervention, Phase "2": Tracheal suctioning was performed only, if there was a clinical need for it. Diameter of the suction catheter was selected not to exceed one half the inner diameter of the artificial airway, providing an internal-to-external diameter ratio of 0.5 in adults **[18]**. In each suctioning episode, three catheter passes only were applied; each of them did not exceed 15 seconds. The catheter was inserted through the tracheal tube until resistance was met, then pulled back slightly. Suctioning pressure was applied only during catheter withdrawal. Immediately before and after suctioning, patients were placed on 100 % oxygen for three minutes and then given 5 breaths with the ventilator. All patients included in the study sample were subjected to the intervention (INS), in which 5 ml of normal saline was instilled before suctioning, immediately before the delivery of the three ventilator breaths given before suctioning. Then, patients will be subjected to the non-intervention (suctioning without saline), four hours after the first intervention, when the patient required again suctioning. Ventilator settings were kept the same during suctioning with and without saline.

Data collection, Phase "2":

Tool (II) was used to collect the following parameters immediately before, immediately after and 5 minutes after suctioning procedure with or without normal saline: HR, SBP, DBP, RR, pH, $PaCO_2$, PaO_2, HCO_3^-, SaO_2, PIP, and Vt. HR was obtained from the cardiac monitor readings. SBP and DBP were measured by a sphygmomanometer manually. An arterial blood gases sample was obtained immediately before, immediately after and 5 minutes after suctioning to determine pH, $PaCO_2$, PaO_2, HCO_3^-, SaO_2. Incidence of cough during suctioning was also documented.

Calculations: Cdyn = Vt/PIP. MAP was calculated as it equals (systolic blood pressure + 2 diastolic blood pressure)/3.

Statistical analysis:

Data were analyzed using SPSS software package version 18.0 (SPSS, Chicago, IL, USA). Quantitative data was expressed using Range, mean, and standard deviation, while Qualitative data was expressed in frequency and percent, McNemar-Bowker was used to analyse the significance between the different stages. Quantitative data was analysed. Not normally distributed quantitative data was analysed using Wilcoxon signed rank test. p value was assumed to be significant at 0.05.

Results:

Phase "1":

Table (1) shows the distribution of the studied sample according to their characteristics. About two thirds of them (68%) are females. Their age ranges from 20 years to 40 years old. Sixteen of them are physicians (14.7%), while 92 of them are nurses (93.3%). Their duration of ICU experience

ranges from 0 years such as those who just started their internship year training to 26 years of experience.

Table (1): Characteristics of studied sample

Characteristic		No. (108)	%
Sex	Male	40	37.0
	Female	68	63.0
Age (year)	Range	20.0 – 40.0	
	Mean ± SD	24.03 ± 4.37	
Position	Practical nurse	14	13.0
	Technical nurse	6	5.6
	Intern nurse	56	51.9
	Nurse supervisor	16	14.8
	Resident physician	12	11.1
	Medical specialist	4	3.6
Years of experiences/year	Range	0.0 – 26.0	
	Mean ± SD	4.19 ± 6.28	

Table (2) demonstrates how often nurses and physicians utilize saline with suctioning. Slightly more than half of nurses and physicians (52%) are utilizing saline frequently with suctioning. Fifty two nurses always or frequently use saline during suctioning; they account 56.5% from the total number of nurses (92 nurses). As for physicians, 12 of them report using saline during suctioning; they account 75% from all physicians (16 physicians).

Table (2):Distribution of studied sample according to their position and utilization of saline

Position	Using saline								Total	
	Always		Sometimes		Rarely		Never			
	No	%	No	%	No	%	No	%	No	%
Practical nurse	0	0	16	23.1	2	6.25	0	0	7	13
Technical nurse	0	0	4	7.7	2	6.25	0	0	3	5.5
Intern nurse	6	75	20	38.5	20	62.5	10	62.5	28	51.85
Nurse supervisor	0	0	6	11.5	6	18.75	4	25	8	14.8
Resident physician	2	25	8	15.8	0	0	2	12.5	6	11.1
Medical specialist	0	0	2	3.8	2	6.25	0	0	2	3.7
Total	8	100	52	100	32	100	16	100	108	100

Table (3) presents nurses and physicians' knowledge regarding advantages and disadvantages of INS. Regarding advantages of the INS, seventy (68.8%) of them (60 nurses and 10 physicians) state that INS stimulates cough reflex. Twenty four (22.2%) nurses and physicians (22 nurses and 2 physicians) report no advantages for the INS. In relation to disadvantages of INS, 68 (64.2%) nurses and physicians indicate chest infection as a complication of INS, while 26 of them (24.5%) report no disadvantages.

Phase "2":

Table (4) represents the characteristics of the studied patients, in which; about two thirds of them are males (65.4%), slightly more than half of them are between 40 and 60 years (53.8%), half of them suffers (50%) from cardiac disorders, and slightly less than half of them (46.2%) have respiratory disorders, and more than half of them (57.7%) have no past history.

Table (5) demonstrates a comparison between hemodynamic response (HR, SBP, DBP, and MAP) to suctioning with and without saline. It is found that HR, SBP, DBP, and MAP do not show any significant change immediately after, or 5 minutes after suctioning in comparison to the before suctioning values , with the absence of any significant difference between suctioning with or without saline.

Table (6) illustrates the comparison between mean differences of change in oxygenation parameters in response to suctioning with and without saline. It is found that pH values significantly increase 5MAS without saline, and decrease IAS with saline (p=0.003, and 0.001; correspondingly). When comparing between pH changes from the base line values in suctioning with and without saline, it is found that there is a significant difference between the two methods of suctioning, in which pH value increases immediately and 5MAS without saline, and decreases immediately and 5MAS with saline (p = 0.04, 0.045, and 0.025; respectively). Although there are no significant differences between $PaCO_2$, PaO_2 and SaO_2 changes after suctioning when comparing between suctioning with and without saline, $PaCO_2$ increases significantly IAS with saline, and PaO_2 and SaO_2 reduce significantly 5MAS with saline (p = 0.04, 0.045, and 0.025; respectively).

Table (7) shows the comparison between mean differences of change in lung mechanics in response to suctioning with and without saline. In relation to respiratory rate values, they increase significantly IAS in both suctioning without and with saline (p=0.021, and 0.032, respectively). Moreover, Cdyn decreases significantly IAS with saline (p=0.013, and 0.005).

Table (8) indicates the incidence of cough or not in response to suctioning with or without saline. This table shows that there is no significant difference between the cough responses to suctioning with or without saline, either immediately or 5MAS.

Table (3) Nurses and physicians' knowledge regarding advantages and disadvantages of INS

Knowledge element		Nurses		Physicians		Total	
		(n=92)	%	(n=16)	%	No=108	%
***Advantage of using saline**	• None	22	23.9	2	12.5	24	22.2
	• Facilitate suctioning large amount of secretions	14	15.22	4	25	18	16.7
	• Stimulate cough reflex	60	65.21	10	62.5	70	64.8
	• Use as doctor order/ for nurses only	2	2.17	0	0	2	1.9
	• Tube obstruction	6	6.52	0	0	6	5.6
***Disadvantages of using saline**	• None	20	21.74	6	37.5	26	24.5
	• Reduce oxygen saturation	12	13.04	4	25	16	15.1
	• Chest infection	60	65.22	8	50	68	64.2
	• Discomfort and pain	30	32.61	4	25	34	32.1
	• Aspiration	6	6.52	0	0	6	5.7

*Multiple responses for more than one choice

Table (4): Distribution of studied cases according to patients' characteristics (n=26)

Characteristic		No.	%
Sex	Male	17	65.4
	Female	9	34.6
Age (year)	< 40	5	19.2
	40 – 60	14	53.8
	> 60	7	26.9
	Range	21.0 – 71.0	
	Mean ± SD	49.12 ± 13.19	
***Diagnosis/disorder**	Respiratory	12	46.2
	Cardiac	13	50.0
	Neurologic	10	38.5
	Renal	3	11.5
	Hepatic	3	11.5
	Metabolic	4	15.4
***Patient's history**	None	15	57.7
	Respiratory	2	7.7
	Cardiac	7	26.9
	Neurologic	2	7.7
	Renal	1	3.8
	Hepatic	0	0.0
	Metabolic	3	11.5

*Multiple responses for more than one diagnosis

Table (5):Comparison between mean differences of change in hemodynamic response to suctioning with and without saline, the immediately and 5 minutes after suctioning values and the before values

Parameter	Without saline			With saline		
	IBS Mean±SD	IAS Mean±SD	5 MAS Mean±SD	IBS Mean±SD	IAS Mean±SD	5 MAS Mean±SD
Heart rate (beat/minute)	95.58 ± 13.79	94.81 ± 19.07	95.15 ± 14.55	97.27 ± 17.22	99.65 ± 22.78	95.77 ± 16.18
p_1		0.455	0.419		0.218	0.861
%change		3.76±22.75	0.69±5.02		1.56±26.80	2.33±15.58
p_2					0.287	0.590
SBP (mmHg)	120.77 ± 28.55	123.62 ± 29.22	124.6 ±26.61	120.19±27.29	127.12±31.25	121.54 ±30.94
p_1		0.589	0.140		0.056	0.772
%change		1.31 ± 12.67	2.94±9.89		4.02±12.37	0.78±14.58
p_2					0.128	0.366
DBP(mmHg)	75.58 ± 14.17	78.08 ± 14.36	76.92 ± 15.10	75.0 ± 18.97	75.38 ± 16.55	72.88 ± 16.38
p_1		0.234	0.321		0.155	0.975
%change		2.50±11.36	0.99±10.06		1.95±26.83	5.36±24.86
p_2					0.394	0.586
MAP(mmHg)	90.064 ± 17.99	93.26 ± 18.54	92.82 ± 17.74	90.06 ± 17.43	92.63 ± 20.33	89.10 ± 20.50
p_1		0.255	0.150		0.077	0.920
%change		2.08±10.97	2.04±8.56		1.25±13.98	3.25±17.15
p_2					0.346	0.231

IBS: immediately before suction, IAS: immediately after suction, 5MAS: 5 minutes after suction
p_1: p value for Wilcoxon signed ranks test between IBS with IAS and 5MAS
p_2: p value for Wilcoxon signed ranks test between the two techniques with the same patients (paired data)
*: Statistically significant at $p \leq 0.05$

Table (6): Comparison between mean differences of change in oxygenation parameters in response to suctioning with and without saline, the immediately and 5 minutes after suctioning values and the before values.

Parameters	Without saline			With saline		
	IBS (Mean ± SD)	IAS (Mean ± SD)	5 MAS (Mean ± SD)	IBS (Mean ± SD)	IAS (Mean ± SD)	5 MAS (Mean ± SD)
PH	7.42 ± 0.11	7.44 ± 0.09	7.45 ± 0.10	7.46 ± 0.11	7.43 ± 0.11	7.45 ± 0.12
p_1		0.866	0.003*		0.001*	0.311
%Change		0.16±0.83	0.32 ± 0.46		0.37±0.50	0.11±0.57
p_2					0.004*	<0.001*
$PaCO_2$ (mmHg)	29.26 ± 8.97	29.65 ± 7.46	28.63 ± 7.08	29.37 ± 9.11	30.82 ± 9.65	30.30 ± 9.32
p_1		0.757	0.576		0.040*	0.148
%Change		2.15±16.22	-1.43±18.41		4.01±11.86	2.33±12.06
p_2					0.328	0.151
PaO_2 (mmHg)	137.89±54.14	139.26 ± 45.57	134.02 ± 54.20	132.52 ± 48.66	123.52 ± 47.98	114.99 ± 51.88
p_1		0.694	0.980		0.137	0.045*
%Change		4.15±46.08	-43.26±192.68		-15.62±38.06	-27.14±48.94
p_2					0.137	0.166
HCO_3^- (mEq/L)	23.99 ± 22.18	19.67 ± 6.72	20.13 ± 6.68	20.79 ± 7.55	20.83 ± 8.24	21.14 ± 8.0
p_1		0.620	0.879		0.666	0.389
%Change		-27.15±149.18	-20.38±124.60		1.50±14.69	0.75±10.37
p_2					0.929	0.990
SaO_2 %	97.37 ± 3.75	98.37 ± 1.45	98.13 ± 2.13	97.77±3.05	96.29 ± 5.22	96.09 ± 5.44
p_1		0.820	0.396		0.071	0.025*
%Change		1.0±3.87	0.73±4.46		-1.80±6.0	-2.05±6.49
p_2					0.107	0.052

IBS: immediately before suction, IAS: immediately after suction, 5MAS: 5 minutes after suction
p_1: p value for Wilcoxon signed ranks test between BS with immediately IAS and 5MAS
p_2: p value for Wilcoxon signed ranks test between the two techniques with the same patients (paired data)

*: Statistically significant at $p \leq 0.05$

Table (7): Comparison between mean differences of change in lung mechanics in response to suctioning with and without saline, the immediately and 5 minutes after suctioning values and the before values

Parameter	Without saline			With saline		
	BS	IAS	5 M AS	BS	IAS	5 MAS
RR (cycle/minute)	22.21 ± 9.10	25.88 ± 9.48	21.19 ± 6.84	26.85 ± 27.43	27.35 ± 11.27	20.96 ± 7.38
p_1		0.021*	0.376		0.031*	0.478
%change		11.66±22.82	-4.70±23.53		11.51±138.34	-41.0±185.91
p_2					1.000	0.523
Compliance (mL/cm H_2O)	29.68 ± 12.25	26.18 ± 10.26	30.0 ± 13.55	29.47 ± 11.42	25.76 ± 10.17	28.06 ± 10.96
p_1		0.124	0.627		0.005*	0.264
%Change		-26.20 ± 68.07	2.01 ± 25.46		-17.49 ± 26.62	-5.97 ± 17.26
p_2					0.909	0.209

IBS: immediately before suction, IAS: immediately after suction, 5MAS: 5 minutes after suction
p1: p value for Wilcoxon signed ranks test between BS with immediately IAS and 5min AS
p2: p value for Wilcoxon signed ranks test between the two techniques with the same patients (paired data)
*: Statistically significant at $p \leq 0.05$

Table (8): Incidence of cough in response to suctioning with or without saline:

Parameter		Without saline	With saline
Cough	Yes (%)	15 (57.7)	17 (65.4)
	No (%)	11 (42.3)	9 (34.6)
@p		0.687	

p: value of McNemar test between suctioning without and with saline
*: Statistically significant at $p \leq 0.05$

4. Discussion:

Phase "1":

Findings of this study phase will be discussed in the following section on the light of other researches regardless the results of phase "2" of the current study. Regarding the INS before suctioning, in the current study, it is obvious that nurses and physicians do not differ a lot in their practices to saline instillation, in which more than half of nurses and three quadrants of physicians always or frequently use saline before suctioning. However, a large number of them reports its risk of chest infection, de-saturation and discomfort, which are reported in many literature [1,19]. This finding may be because nurses and physicians assume that INS has a role in stimulating cough reflex. In accordance with the current study, **Schwenker *et al.,*** study [16], who conducted alike survey on nurses and respiratory therapist, indicated that high responses from respiratory therapists showed that INS stimulates cough reflex. **Schwenker *et al.,*** commented on this finding that if the only benefit of instillation of saline before suctioning is the stimulation of a cough reflex, then INS would not be of a value to a paralyzed patient.

In addition, a number of nurses indicate that they sometimes use saline before suctioning because of the physician's order of utilizing saline that sometimes be written into patient's chart as a routine care. Another factor that leads to frequent use of saline with suctioning is the research findings' conflicts on saline utilization. In line with the current research, **Reeve *et al.*** [20] who conducted a similar survey on the practice of INS, reported that the INS continues to be used by physiotherapists as an aid to clearance of secretions. They attributed this practice as well to the lack of high quality research evidence supporting or not the continuation of this practice. Finally, it could not be also ignored that there are a number of nurses and physicians still believe that INS is risk free and can lubricate secretions, consequently facilitating its removal. However, Ackerman and Mick (1998)[6] indicated that saline and secretions cannot be mixed together. **Halm and Krisko-Hagel** [19] added that the best-known interventions for managing thick tenacious secretions and preventing mucus plugs in ventilator-dependent patients are hydration, adequate humidification, use of mucolytic agents, and effective mobilization instead of subjecting the patient to the harm of saline instillation.

Contrary to the current study, **Schwenker *et al.,*** [16] referred to the inability of most of their research respondent to recognize chest infection as a risk of INS. These differences in perception may be because, in the current study, a large number of nurses are interns who received during their

undergraduate training adequate information regarding saline related risks including; infection and pneumonia. For the physicians, a comment written by one of them is that a recommendation indicated by the last anaesthesia and intensive care conference is not to utilize saline during suctioning as it induces risk of chest infection. So these conference recommendations might raise their awareness to chest infection as a side effect of INS. In conclusion, it is apparent that a considerable number of nurses and physicians can recognize the most common advantages and disadvantages of INS; however, they continue its use before suctioning. Therefore, they need to be more aware about all the complications of INS, and of the alternative techniques to the INS that do not cause any harm to the patient.

Phase "2":

The following section will focus on the comparison between effects of suctioning with and without saline on a number of physiological response parameters. In relation to hemodynamic response, it is found that HR, SBP, DBP, and MAP do not change significantly immediately or 5MAS in both methods and do not differ significantly from method to another. These findings are in accordance with other studies [9, 21] showing that there is no statistical significant difference between the effect of suctioning with or without saline on HR or blood pressure and no significant changes are detected after suctioning. Contrary to these findings, **Akgul and Akyolcu** [22] and **Ackerman** [23] reported a statistical significant increase in HR post suctioning either with or without saline instillation. Also, **Ackerman** [23] reported an elevation in BP after suctioning with saline. Several causes might justify this difference. First, the current study involved several actions preventing suctioning associated hypoxemia which is considered as one of the main causes to hemodynamic changes after suctioning [24]. Second, differences in the way of conducting suctioning procedure are also considered. For example, the technique used for hyperoxygenation, depth of catheter insertion, amount of saline installed may result in different findings. Finally, **Ackerman** [23] emphasized the effect of the statistical analysis test which may result in different findings. They pointed out that in his study, using Wilcoxon signed ranks test did not result in any significant relations in comparison to a two tailed T test.

Regarding changes in oxygenation parameters, the significant decrease in pH values IAS with saline may be related to the significant elevation in $PaCO_2$ associated suctioning with saline, IAS. Furthermore, a statistical significant difference was found when comparing between suctioning with and without saline in relation to the pH value of change. It was found that pH increased IA, and 5MAS without saline, and decreases IAS, and 5MAS with saline. This finding may be due to the elevation of the $PaCO_2$ values IA, and 5MAS suctioning with saline due to inadequate gas exchange secondary to INS that may occlude terminal airways [25]. Contrary to this finding, **Akgül and Akyolcu** [22] found that there is a significant increase in pH following suctioning with saline which was not justified in their study. In relation to $PaCO_2$, PaO_2 and SaO_2 changes after suctioning with and without saline, $PaCO_2$ increases significantly IAS, and PaO_2 and SaO_2 decrease significantly 5MAS with saline which might result from the instillation of saline into the lungs that negatively affects gas exchange [26,27]. In accordance with these results, **Halm and Krisko-Hagel**[19] reported that studies [7, 22, 26, 27] indicated that using normal saline was significantly associated with decreased oxygenation and desaturation that worsened over time after suctioning.

Concerning significant increases in RR occurring IAS in suctioning with and without saline, this finding may be attributed to discomfort and distress caused by the suctioning procedure itself [27]. This is in accordance with **Morrow *et al.*** [28] who reported that spontaneous RR increases significantly after suctioning due to stress and discomfort. In relation to changes in Cdyn, it shows a significant reduction, IAS with saline. This finding is in line with **Cunha-Goncalves** and colleagues [29] who reported a significant decrease in Cdyn after suctioning with saline. This reduction in Cdyn may be attributed to several factors. **Fernandez *et al.*** [25] indicated that the mechanical suctioning procedure itself and the tube disconnection produce atelectasis [28,25]. Dyhr, Bonde, and Larsson (2003) [30], **Martoft *et al.*** [12] and **Fernandez *et al.*** [25] provided other explanation for the observed lung mechanics deterioration following INS; is that saline entrapment causes occlusion of the terminal airways or even micro disturbances in the surfactant system. Therefore they emphasized the need for a lung recruitment maneuver and ventilator adjustments to find optimal PEEP after saline instillation/ suctioning and providing hyperinflation, in order to avoid lung collapse and worsening of lung function and arterial oxygenation. However hyperinflation is controversial due to its possible effect if associated with INS on the incidence of chest infection [8,28-30].

Finally, absence of significant differences between cough response to suctioning with or without saline may prove that INS does not stimulate cough reflex, and the suctioning procedure itself is the stimulator of cough, including; suction catheter insertion and application of negative pressure. This

result is in line with **Gray *et al.*[9]** who reported that cough could be stimulated by the suctioning procedure alone.

Limitations of the study: for phase "1" of the study, the response rate for the physicians to the questionnaire was lower than 50% of them. For phase "2" of the study, static compliance and resistance were not measured because of most of the ventilators cannot measure accurately the flow rate.

5. Conclusion and recommendations:

Based on the findings of this study, it can be concluded that nurses and physicians frequently use saline before suctioning although, a large number of them recognize the most common advantages and disadvantages of INS. Yet, some of them still have inaccurate knowledge regarding INS. Regarding INS, it carry out several risks, including; significant elevation in $PaCO_2$ immediately after suctioning and reduction in oxygen tension and saturation 5 minutes after suctioning. Therefore this study recommends; conducting in-service education to nurses and physicians on this topic raising their awareness on risks on INS and available alternatives to INS. Instead of using normal saline to decrease the viscosity of secretions prior to suctioning, efforts should be made to ensure adequate hydration, adequate humidification, use of mucolytic agents, and effective mobilization. Restoring lung compliance by providing post-suction hyperinflation is necessary to regain lung compliance and prevent atelectasis; however, this recommendation may require further research on its effect on the incidence of infection and hemodynamics. Further researches have to be conducted examining the effect of INS on oxygenation and lung dynamic parameters after 5 minutes of suctioning.

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5/20/2011