Evaluation and Predictors for Nasogastric Tube Associated Pressure Ulcers in Critically Ill Patients

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ABSTRACT: **Backgound:** Nasal device-related pressure ulcers are scarcely addressed in the literature.

Objective: To assess the prevalence and severity of cutaneous and mucosal nasogastric tube (NGT)-associated pressure ulcers (PU) in critically ill patients and to define predictors for their formation.

Methods: A single center observational study of intensive care unit patients with a NGT for more than 48 hours was conducted. Nasal skin was evaluated for PU. Ulcers were graded according to their depth. Consenting patients underwent a nasoendoscopic examination to evaluate intranasal mucosal injury.

Results: The study comprised 50 patients, 17 of whom underwent nasoendoscopic examination. Mean time of NGT presence in the nose was 11.3 ± 6.17 days. All patients had some degree of extranasal PU, 46% were low grade and 54% were high grade. Predictors for high grade extranasal PU compared to low grade PU were higher peak Sepsis-related Organ Failure Assessment (SOFA) scores (11.52 vs. 8.87, $P = 0.009$), higher peak C-reactive protein (CRP) levels (265.3 mg/L vs. 207.58, $P = 0.008$), and bacteremia (33.3% vs. 8.7%, $P = 0.037$). The columella was the anatomical site most commonly involved and the most severely affected. The number of intranasal findings and their severity were significantly higher in the nasal cavity containing the NGT compared to its contralateral counterpart ($P = 0.039$ for both).

Conclusions: NGTs cause injury to nasal skin and mucosa in critically ill patients. Patients with bacteremia, high CRP, and high SOFA scores are at risk for severe ulcers, warranting special monitoring and preventive measures.

IMAJ 2018; 20: 731–736

KEY WORDS: critically ill patients, intensive care unit, nasal pressure ulcers, nasogastric tube (NGT), pressure ulcer (PU)

Critically ill patients are at high risk of developing skin breakdown and pressure ulcers (PU) [1], especially medical device related pressure ulcers (MDRPU). Risk factors for MDRPU in this population include impaired mobility, decreased sensory perception, poor nutritional status, impaired circulation, and oxygenation with the addition of securement tightness and humidity/heat developing between the skin and the device [1-6].

NGT-associated PU (NGaPU), comprising 8% of MDRPU [5], are frequently neglected. Studies have reported incidence rates ranging from 10% to 29% [7,8]. Duration of NGT presence in the nose [9] and the bridle fixation method [8] were associated with NGaPU development. Existing studies measured the prevalence of cutaneous ulcers on the skin of a patient's nose [7-9]. To the best of our knowledge, no study yet has attempted to measure the prevalence and severity of NGT-associated mucosal injury.

Mucosal NGaPU could potentially cause stenosis of the nostril/vestibule, nasal septum perforations, and nasal synechia in addition to scarring that could lead to nasal deformity [10]. Such injuries may cause a poor aesthetic result and functional chronic nasal airflow obstruction [11-13]. Although it is a rare complication, it is challenging to correct. A myriad of correction techniques have been described. Restenosis is a common and frustrating outcome requiring serial or long-term stenting for its prevention [14].

The goal of our study was to assess the prevalence and degree of cutaneous and mucosal NGaPU as well as to explore factors associated with NGaPU formation in critically ill patients. We believe our study may help to improve the quality of care within hospital intensive care units (ICUs), and may help prevent unnecessary morbidity for patients with NGT.

PATIENTS AND METHODS

The study population included patients admitted to our institutional ICU from May 2013 to February 2014 who had an NGT placed for more than 48 hours. The study was approved by the institutional ethics committee. All patients signed an informed consent form. Our cohort of patients admitted to the ICU included surgical (both cardiac and non-cardiac surgery) and internal medicine patients with severe respiratory failure. Exclusion criteria included patients admitted to the ICU who already had an NGT; evidence of prior nasal pressure ulcers;

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patients who had a feeding tube placed trans-orally due to nasal pathologies, skull base injuries, or epistaxis; and patients who either declined to participate in the study or who were unable to provide consent. Data collected included age, gender, cause for admission (non-cardiac surgery, cardiac surgery, or internal/other), presence of diabetes or peripheral vascular disease, use of noradrenalin (defined as none, low levels < 10 mcg/min, and high levels ≥ 10 mcg/min), nutrition type (enteral/parenteral/both), occurrence of bacteremia or ventilator associated pneumonia (VAP) during admission, presence of non-nasal PU, and duration the NGT was present in the nose. In addition, laboratory studies including C-reactive protein, albumin, and pre-albumin levels were recorded. For evaluation of a patient's systemic condition, the Acute Physiological Assessment and Chronic Health Evaluation (APACHE II) [15] and Sequential Organ Failure Assessment (SOFA) [16] scores were used.

A uniform NGT type (Unomedical/ConvaTec®, Deeside, UK) and size (14F) was used on all patients. NGT were placed by experienced ICU nurses or physicians. Naso-Fix™ securement device (ConvaTec®, Deeside, UK) taped around the tube and attached to the patient's dorsum of the nose was used for NGT fixation. During the time period the NGT was in place, any ulcers identified by the nursing staff prompted readjustment of the NGT or replacement of the fixation tape to prevent ulcers from exacerbating. Removal of the NGT was usually performed when the patient was able to feed orally, usually 24 to 48 hours after being successfully extubated.

After a medical decision was made that the patient no longer required an NGT, it was removed and patients were offered to participate in the study. Patients were examined for cutaneous PU, defined as ulcers on the skin of the nose that are evident with non-instrumental inspection. Cutaneous ulcers were graded according to the criteria outlined by the European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel (2009) [17]. For the purpose of statistical analysis, grades 1+2 PU were considered low grade and grades 3+4 were considered high grade.

After the external examination, patients who enrolled to the study were asked to undergo a nasoendoscopy. Patients who agreed to undergo a nasoendoscopy were examined using a portable flexible endoscope (FNL-10RBS Pentax Medical FNL, HOYA, Tokyo, Japan; or 11101SK2 Karl Storz Gmbh & Co. Tuttlingen, Germany) no later than 48 hours after removal of the NGT. The mucosa of the nasal cavity and nasopharynx were examined and any erosions/ulcers of the nasal mucosal lining were recorded. Since no grading system for mucosal ulcers exists [17], the mucosal injury was graded according to the following scale: 0 = normal mucosa; 1 = superficial erosion, which was defined as fibrin covered erosions on the mucosa; 2 = deep erosion, which was defined as erosions involving tissue deeper than the mucosa; 3 = granulation tissue; and 4 = exposed cartilage/bone. The nasal cavity was divided into anatomical subsites. The columella, alla of the nares, anterior septum, inferior and middle turbinates, posterior septum (defined as the septum posterior to the anterior tip of the middle turbinate), choana, and nasopharynx each graded separately. The contralateral NGT-free nasal cavity served as control.

Mucosal ulcers in the nasal cavity that contained the NGT were compared with the contralateral nasal cavity, both in terms of the absolute number of pathological mucosal ulcers and of their cumulative severity score. For purposes of statistical analysis, nasal cavities with no ulcers received a score of 0, while nasal cavities with ≤ 1 ulcers or a severity score ≤ 1 received a score of 1.

STATISTICAL ANALYSIS

Based on data in the literature [9] pertaining the expected differences between patients with and without nasal pressure ulcers, a power analysis was performed. A sample size of 40 subjects was required for a power (1-b) of 0.95 with an α = 0.05, single-tailed. The chosen sample size for our study was 50 patients. Continuous variables are presented as mean ± standard deviation. Mann–Whitney test was used for comparison analysis of two independent non-normally distributed continuous variables between two groups, and Kruskal–Wallis test was used when three variables were compared. Normally distributed continuous variables were compared using *t*-test. Non-continuous variables were compared using chi-square test. Comparison between the ipsilateral nostril and contralateral nostril was performed with the McNemar nonparametric test. The Wilcoxon test was used to compare two variables in the same group.

Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 21 (SPSS, IBM Corp, Armonk, NY, USA).

A two-tailed *P* value < 0.05 was considered statistically significant.

RESULTS

Fifty patients were recruited to the study, 36 were male (72%). The mean age was 63.4 ± 14.81 years. The majority of patients were surgical patients (n=26, 52%), followed by medical (n=13, 26%), and post-cardiac surgery patients (n=11, 22%). In total, 25 patients (50%) had diabetes and 9 (18%) had peripheral vascular disease; 37 patients (74%) received enteral feeding, 11 (22%) received both enteral and parenteral feeding, and 2 (4%) received only parenteral feeding. In addition, 11 patients (22%) had bacteremia and 7 (14%) had acquired VAP. All patients underwent orotracheal intubation. Mean duration of NGT presence in the nose was 11.3 ± 6.17 days. Mean APACHE II score was 20.5 ± 6.6, which is related with an expected mortality of 39.5% ± 19.7%. Mean peak SOFA score was 10.3 ± 3.63. Mean minimal albumin level and pre-albumin levels were 2.1 ± 0.49 g/dl and 7.5 ± 3.98 mg/dl, respectively. Maximal C-reactive protein (CRP) scores were 238.7 ± 78.09 ml/L. Forty patients (80%) required inotropic support, either high level (n=26, 52%) or low level (n=14, 28%); 14 patients (28%) had non-nasal PU.

EVALUATION OF CUTANEOUS NGAPU

All patients had some degree of cutaneous PU. PU were graded 1 in 12%, 2 in 34% (total 46% low grade ulcers), 3 in 52%, and 4 in 2% (total 54% high grade ulcers). Figure 1 shows an example of a grade 2 cutaneous PU.

A comparison of patients with high-grade and low-grade cutaneous NGaPU is shown in Table 1. Factors significantly associated with high-grade NGaPU were higher peak SOFA scores (8.87 ± 3.0 in the low-grade compared to 11.52 ± 3.78 in the high-grade group, P = 0.009), higher peak CRP levels

Figure 1. Cutaneous pressure ulcer. Grade 2 cutaneous pressure ulcer of the columella **[A]** lateral view, **[B]** anterior view with dorsiflexion of the nasal tip

Table 1. Comparison between high grade and low grade NGaPU

		All patients		High-grade PU		Low-grade PU		
		Number	%	Number	%	Number	%	***P* value**
Patients		50	100	27	54	23	46	
Gender	Men	36	72	20	55.5	16	44.4	0.723
	Women	14	28	7	50	7	50	
Age, years*		63.4 ± 14.81		60.7 ± 14.2		66.5 ± 15.4		0.066**
Patient type	Internal	13	26	5	38.5	8	61.5	0.088
	Surgical	26	52	13	50	13	50	
	Cardiac surgery	11	22	9	81.8	2	18.2	
Co-morbidities	DM	25	50	14	56	11	44	0.777
	PVD	9	18	5	55.6	4	44.4	0.918
Vasopressor dose	None	10	20	3	30	7	70	0.066
	Low	14	28	6	42.9	8	57.1	
	High	26	52	18	69.2	8	30.8	
Nutrition	Enteral	37	74	19	51.4	18	48.6	0.768
	Enteral + parenteral	11	22	7	63.6	4	36.4	
	Para-enteral	2	4	1	50	1	50	
Bacteremia		11	22	9	81.8	2	18.2	0.037
VAP		7	14	3	42.9	4	57.1	0.524
PU in other site		14	28	9	64.3	5	35.7	0.278
NGT days*	Days	11.3 ± 6.17		11.89 ± 5.618		10.7 ± 6.96		0.241**
APACHE II score*		20.5 ± 6.6		21.37 ± 6.58		19.57 ± 6.71		0.343
Suspected mortality (%)		39.5 ± 19.7		42.2 ± 20.06)		36.57 ± 19.7		0.343
Minimal albumin*	g/dl	2.1 ± 0.49		2.11 ± 0.5		2.17 ± 0.57		0.654**
Minimal pre-albumin *	mg/dl	7.5 ± 3.98		7.41 ± 4.02		7.83 ± 4.33		0.725
Maximal CRP level*	mg/L	238.7 ± 78.09		265.3 ± 74.6		207.58 ± 73.45		0.008
Peak SOFA score*		10.3 ± 3.63		11.52 ± 3.78		8.87 ± 3.0		0.009

*Values presented are mean ± standard deviation

**Age, minimal albumin level, and duration of NGT presence in nose (days) were compared using Mann–Whitney test. All other continuous variables were normally distributed and were compared using two-tailed *t*-test

APACHE = Acute Physiological Assessment and Chronic Health Evaluation, CRP = C-reactive protein, DM = diabetes mellitus, MRSA = methicillin resistant *Staphylococcus aureus*, MSSA = methicillin sensitive *Staphylococcus aureus*, NGaPU = Nasogastric tube associated pressure ulcer, NGT= nasogastric tube, PU = pressure ulcer, PVD = peripheral vascular disease, SD = standard deviation, SOFA = Sequential Organ Failure Assessment, VAP = ventilator associated pneumonia

Table 2. Distribution of pathologic endoscopic injuries in the mucosa of the nasal cavities

Total number of mucosal findings								
Anatomical subsite	**Columella**	**Alla of the nares**	**Anterior septum**	**Inferior turbinate**	**Middle turbinate**	**Posterior septum**	**Choana**	**Nasopharynx**
All nasal cavities	13	5	8	6	6	4	0	4
Ipsilateral nasal cavities*	10	4	7	5	6	4	0	3
Contralateral nasal cavities*	3	1	1	1	0	0	0	1
Endoscopic mucosal injury severity score in the nostril ipsilateral to the nasogastric tube								
Patient 1	1	0	0	0	1	0	0	1
Patient 2	2	0	0	0	1	0	0	0
Patient 3	1	1	0	1	0	0	0	0
Patient 4	0	0	0	0	0	0	0	0
Patient 5	0	0	0	0	2	1	0	0
Patient 6	1	0	0	0	0	1	0	0
Patient 7	1	0	1	0	0	0	0	0
Patient 8	0	0	1	0	0	0	0	0
Patient 9	1	0	0	0	2	2	0	0
Patient 10	2	2	1	0	0	0	0	0
Patient 11	0	0	0	0	0	0	0	0
Patient 12	4	1	1	0	1	0	0	2
Patient 13	0	4	0	3	1	0	0	0
Patient 14	0	0	0	0	0	0	0	0
Patient 15	2	0	1	1	0	2	0	0
Patient 16	2	0	1	1	0	0	0	0
Patient 17	0	0	1	1	0	0	0	1

Scoring system: 0 = normal mucosa, 1 = superficial erosion, 2 = deep erosion, 3 = granulation tissue, 4 = exposed cartilage/bone
*Ipsilateral/contralateral to the nostril in which the nasogastric tube was placed

(207.58 ± 73.45 in the low-grade vs. 265.3 ± 74.6 mg/L in the high-grade group, $P = 0.008$), and bacteremia (18.2% in low-grade vs. 81.8% in high-grade group, $P = 0.037$). A borderline significant association was observed between high vasopressor consumption levels and high-grade NGaPU (69.2% high-grade PU in the high vasopressor dose group compared to 30.8% in the low vasopressor dose group, $P = 0.066$). Study sample size precluded performing a multivariate analysis for predictors of NGaPU. A trend for association was found between ICU admission indication (medical/surgical/cardiac) and severity of NGaPU: higher rates of severe NGaPU were observed in the cardiac group (81.8% high-grade PU in the cardiac surgical group compared to 50% in the non-cardiac surgical group and 38.5% in the medical group, $P = 0.088$). No difference was found in the number of NGT days in the nose, APACHE score, or minimal albumin/pre-albumin levels of the low-grade compared to the high-grade PU groups.

EVALUATION OF MUCOSAL NGAPU

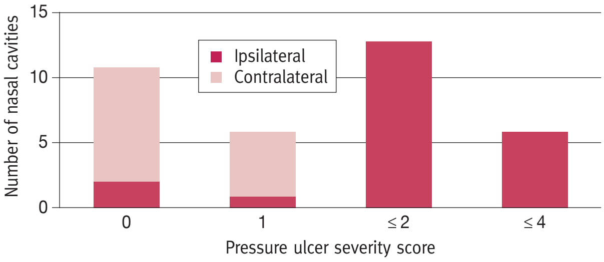
Seventeen patients consented to undergo nasoendoscopy. No statistically significant differences were found in the age, gender, patient type, co-morbidities, vasopressor use, and incidence of bacteremia in the patients who consented to undergo nasoendoscopy compared to the patients who refused to be examined.

Of the cohort, 15 of 17 patients (88.2%) showed evidence of mucosal injury in the NGT-occupied nostril. The distribution of pathologic endoscopic findings in the mucosa of the nose and nasal cavities is presented in Table 2. The columella was the most common site showing mucosal injury and the most severely affected. There was a significant difference both in total amount of pathological mucosal findings (39 mucosal injury sites in ipsilateral nasal cavities compared to 7 sites in the contralateral nasal cavity, $P = 0.039$) and the severity of the findings between the nasal cavity that contained the NGT and the contralateral nasal cavity (mean severity score 1.23 in ipsilateral nasal cavities compared to 0.6 in contralateral nasal cavities, $P = 0.039$) [Figure 2].

DISCUSSION

Our study examined the prevalence and severity of nasal cutaneous and mucosal injury associated with NGT placement. To the best of our knowledge, this is the first study to endoscopically examine the effects of NGT on the nasal mucosal surfaces in critically ill adult patients.

Figure 2. Severity of mucosal injury scores in the nasal cavity. Severity score values are the sum of the scores of all involved subsites in a nasal cavity. Ipsilateral/contralateral relative to the nostril in which the nasogastric tube was placed



All patients in our study presented some degree of nasal injury. A current literature review produced only two studies examining the prevalence of NGaPU in ICU patients. They reported a prevalence of 10% to 29% [7,8], which was significantly lower than what we observed in our study. However, the examined cohorts were different. Seder and colleagues [8] examined only surgical patients and their results included a lower median duration time of NGT presence in the nose (median 6–9 days compared to 11.3 in our cohort). The cohort examined by Esperón Güimil and co-authors [7] was younger than our cohort (54.14 compared to 63.4 years), and the patients in their study consumed fewer inotropes. Furthermore, the fixation method and NGT type differed in all studies. Seder's group used 10F NGT while our cohort was intubated with 14F tubes. The observational methodology of our study precluded testing the effect of different sizes of NGT on NGaPU formation. Future interventional studies are warranted to establish whether NGT caliber actually effects NGaPU development. Seder also compared two NGT fixation methods, with ulcers evident only in the bridled group compared to the group with adhesive tape fixation [8]. Fixation method or NGT size were not mentioned in Esperón Güimil's study. Finally, methods for ulcer grading were different. Seder's group used a binary classification. Esperón Güimil's cohort used the EPUAP classification. Their ulcers consisted of only low grade ulcers (45% grade 1 and 55% grade 2).

Despite the aforementioned differences, we considered that the higher NGaPU rate in our study could also have resulted from our ICU's NGT nursing care, which prompted reconsiderations of our nursing care technique. Future randomized studies with direct comparison of NGT fixations are needed to improve quality of care.

In our study, a significant association for severe NGaPU was found in patients with higher peak SOFA scores, higher peak CRP levels, and bacteremia. These findings imply that NGaPU severity may be associated with systemic factors rather than local factors such as duration of time with NGT. Our findings are supported by other studies that demonstrated that cutaneous pressure ulcers are correlated with disease severity [18-20], and APACHE II score [18,19] in particular. Interestingly, in our study it was the SOFA scores and not the APACHE II scores that were associated with NGaPU severity. In contrast to the APACHE score, which reflects the patient's status only at admission, the SOFA score is performed daily during ICU admission and enables clinicians to better reflect peak morbidity throughout the admission. No correlation was found between NGaPU severity and duration of NGT in the nose or nutritional state indicators such as albumin/prealbumin levels. These findings are in contrast to the study by Esperón Güimil and colleagues [7], in which the only factor associated with the development of NGaPU was the length of time the NGT was present in the nose. This discrepancy might be explained by the rapidity of the appearance of NGaPU. NGaPU appeared as early as 72 hours after NGT placement.

Similar results have been shown in a study regarding the development of CPAP-associated nasal PU in critically ill neonates [9]. In the first days of hospitalization, the patient usually achieves peak morbidity. It is during these critical first days that the damage to the nasal skin and mucosa is caused, rendering other factors, such as nutritional status or duration of NGT presence, less relevant.

When analyzing NGaPU distribution, the columella was found to be the most frequently and severely affected subsite. The nasal mucosa is known to be highly vascular [21]. However, blood supply to the tip of the nose is mainly derived from terminal branches of the facial arteries with inconsistent collaterals from the ophthalmic arteries [22]. This end organ-like blood supply pattern renders the nasal tip more sensitive to necrosis. Combined with the effects of vasoconstrictive medication, this could be a reason the columella was more prone to NGaPU.

PU substantially impact patient morbidity [17,18]. In our current era in which morbidity and well-being (rather than survival alone) are of growing importance [23,24], the prevention of PU is paramount. A variety of strategies have been proposed to prevent MDRPU, including correct positioning and care of equipment, use of thin dressings or barrier products underneath the device to reduce moisture, friction and shear, use of pressure reducing dermal gel pads, regular and frequent inspection of the skin, and temporary loosening of the device to allow a thorough skin assessment [23]. NGT should be secured so that the tube is free floating in the nare, and not pressing against the cheek or ear when patients are laid on their side [24]. However, the aforementioned techniques have not been studied in relation to the mucosal surfaces. Mucosal NGaPU monitoring requires endoscopic examinations. However, this monitoring regimen is not feasible in most medical centers due to logistic considerations, its invasive unpleasant nature, and costs. We suggest two possible solutions for prevention of NGaPU: either routinely alternating the nares in which the NGT is placed or placing the NGT trans-orally in the already intubated anesthetized patients, thus bypassing the nose altogether. These suggestions should be compared to the traditional NGT maintenance in future randomized studies.

Our study has several limitations. The relatively small sample size of patients precluded performing a multivariate analysis. The patient population included only patients who were well enough to have their NGT removed and to sign an informed consent. These criteria might have caused a selection bias toward healthier patients. Furthermore, the lack of documentation of mucosal findings prior to NGT insertion and of the number of unsuccessful insertion attempts and the nostril in which they were performed made differentiating between mucosal injury caused by traumatic NGT insertion and mucosal PU difficult. Finally, our study design did not include a follow-up examination, which prevented the evaluation of the natural history of NGaPU. Further studies are required to establish proper monitoring, management, prevention, and follow-up plans for critically ill patients with NGaPU.

CONCLUSIONS

The presence of an NGT in the nose is associated with both cutaneous and mucosal injury. NGaPU may be much more common than presumed before, and its severity correlates with systemic factors and disease extent. We believe the findings of the study may result in better quality of care for these patients and may aid in identifying patients at risk.

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Capsule

scTrio-seq identifies colon cancer lineages

To better design treatments for cancer, it is important to understand the heterogeneity in tumors and how this contributes to metastasis. To examine this process, **Bian** et al. used a single-cell triple omics sequencing (scTrio-seq) technique to examine the mutations, transcriptome, and methylome within colorectal cancer tumors and metastases from 10 individual patients. The analysis provided insights into tumor evolution, linked DNA methylation to genetic lineages, and showed that DNA methylation levels are consistent within lineages but can differ substantially among clones.

Science 2018; 362: 1060

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