Original Article

Prevalence of major structures injury in thyroid and neck surgeries: a national perspective

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Background: The objectives of the study is to examine the prevalence and burden of major structures injury (pharynx, esophagus, trachea, larynx, lymphatic, vessels & nerves) in patients who underwent thyroid, parathyroid, and neck dissection surgeries in the United States.

Methods: The study is a retrospective cross-sectional analysis utilizing the Nationwide Readmissions Database, 2010–2015. The study population included adults (≥18 years) patients who underwent thyroid, parathyroid, and neck dissection surgeries.

Results: A total of 54,443 patients were included. Major structures injury was reported in 221 (0.48%) patients. The injured structures were vascular (0.22%), lymphatic (0.18%), pharynx/esophagus (0.06%), neural (0.03%), and trachea/larynx (0.002%). The risk of injury increased annually during the study period (OR: 1.29, 95% CI: 1.16, 1.44, P<0.001). The risk of injury was highest in patients who underwent thyroidectomy with neck dissection (1.01%) or neck dissection alone (1.81%) (P<0.001 each). The risk was also highest for patients with a head and neck cancer diagnosis (OR: 1.80, 95% CI: 1.24, 2.61, P=0.002). Patients with those injuries had a higher prevalence of blood transfusion (2.82% *vs.* 0.17%), postoperative fistula (3.10% *vs.* 0.03%), readmission (28.90% *vs.* 3.59%), and postoperative mortality (0.87% *vs.* 0.06%) (P<0.05 each). Management of patients with those injuries was associated with a longer hospital stay by 4.86±0.48 days (P<0.001), and a higher cost by $16,151.00±173.36 (P<0.001).

Conclusions: Injuries of major structures in thyroid and neck surgeries are more prevalent in cancer patients. There has been a recent increase in the risk of such injuries in the United States. Those injuries are associated with significant clinical and economic burden.

Keywords: Head and neck surgery; nerve injury; chyle leak; esophagus injury; vascular injury

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Introduction

Currently, there is an estimated 234 million operations being performed globally on a yearly basis (1). As the amount and complexity of procedures increases, emerging research has been focusing on surgical safety and clinical outcomes. Intraoperative iatrogenic injuries can be inconsequential, while others can result in a grave morbidity and mortality. In 2012, over one trillion dollars were spent

on intragenic medical complications (2,3). The associated morbidity with surgical injurie is harder to quantify, but nevertheless the consequences can be devastating (4). Prior studies have suggested that at least half to two-thirds of all complications associated with surgeries are avoidable (1,5,6). Increasing evidence supports that a surgeon's expertise and procedure volume is associated with favorable clinical outcomes (7-9).

We have previously shown that 0.3% of all surgical-related injuries were due to procedures performed in the ear, nose, mouth, and pharynx (10). In a survey of 466 members of the American Academy of Otolaryngology-Head and Neck Surgery, reported errors were the result of technical misadventure 19.3% of the time (4). Neck dissection, thyroid surgery, and parathyroid surgery are commonly performed procedures and not without considerable inherent risks. Iatrogenic injuries during these procedures can cause functional impairment and potentially impact disease survival (11). The prevalence of major structure injury for these procedures is not well described at the national level. The objective of the present study was to identify the prevalence of major structure injury following neck dissections, thyroid, and parathyroid surgeries. We also aimed to identify the associated risk factors and the associated burden at the national level. We present the following article in accordance with the "STrengthening the Reporting of OBservational studies in Epidemiology" reporting checklist (available at http://dx.doi.org/10.21037/gs-20-369).

Methods

This study is a retrospective cross-sectional analysis utilizing the Nationwide Readmissions Database (NRD) for the years 2010–2015 (12). The NRD is a part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (12). The NRD is a unique and powerful database designed to support various types of analyses of national readmission rates for all payers and the uninsured (12). The database includes discharge data from 27 geographically dispersed states, accounting for 57.8% of the total U.S. resident population and 56.6% of all U.S. hospitalizations (12). Additionally, the database allows for weighted analysis that has been utilized in this project to provide a better estimation of national outcomes (12). The NRD tracks patients across the sampled hospitals within a calendar year for any readmission (12). This database addresses a large gap in health care data - the lack of nationally representative information on hospital readmissions for all ages (12). The NRD consists of publicly available de-identified data that does not meet the criteria of human subject research and does not meet the criteria for review by the University of Iowa Institutional Review Board. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

The main objectives of the study are to examine the prevalence of and the associated outcomes with major structure injuries reported in patients admitted for thyroid, parathyroid, or neck dissection surgery. A major structure injury was defined using the International classification of diseases, 9th edition, codes (ICD-9) and included: vascular injuries (ICD-9: 900, 904.9, 998.11), trachea/larynx (ICD-9: 807.5, 807.6, 874.0), pharynx/esophagus injuries (ICD-9: 478.29, 530.4), lymphatic injury (ICD-9: 457.8), and neural injuries (ICD-9: 957.9, 957.0, 951.4, 951.6, 951.7, 951.8, 951.9, 953.4). All those codes indicate injury that was not part of the planned resection and they also refer to visible damage that could be encountered intraoperatively and does not include physiological injuries such as nerve stretching or a simple postoperative hematoma. Thyroid, parathyroid, and neck dissection surgeries were identified using the following ICD-9 codes: 06.2, 06.3, 06.4, 06.6, 06.7, 06.8, 40. All admissions were checked for completeness of data. Admissions with missing values for the study parameters were excluded.

Outcomes of interest included: (I) risk of requiring blood transfusion (not reported, reported), (II) risk of requiring tracheostomy (not reported, reported), (III) risk of readmission within 30 days postoperatively, (IV) risk of postoperative mediastinitis (ICD-9: 519.2) within 30 days, (V) risk of postoperative subcutaneous emphysema (ICD-9: 998.81) within 30 days, (VI) risk of postoperative fistula (ICD-9: 998.6) within 30 days, it should be noted the used code does not specify the type of fistula but indicates it developed postoperatively (VII) inpatient mortality risk within 30 days postoperatively, (VIII) total length of hospital stay in days, and (IX) cost of health services provided during the admission—the database includes hospital charges associated with each admission as well as cost-to-charge ratio determined for each hospital that allows conversion of charges values to cost values, all cost values were adjusted for inflation rate to reflect 2018 U.S dollar value using Bureau of Labor Statistics inflation calculator (12,13).

The independent factors that were assessed for their association with the risk of injury included: (I) age: 18 – <45, 45–55, 55–65, ≥65 years; (II) gender: male,

female; (III) modified Charlson comorbidity index score (CCIS), classified into: 0, 1, ≥2 (14); (IV) Overweight: not reported, reported; (V) tobacco use history: not reported, reported; (VI) Diagnosis: cancer, benign, toxic thyroid disease, parathyroid disease; (VII) type of surgery: thyroid lobectomy, total thyroidectomy, parathyroidectomy, neck dissection, thyroidectomy with neck dissection; (VIII) hospital volume defined as the number of surgeries performed in each hospital per year, classified by applying quartile classification with rounding to the nearest 10 to avoid introducing bias, the classification included: low-volume hospitals (<25th percentile: 1–20 surgeries/yr), intermediate-volume hospitals (25th – <75th percentiles: 21–100 surgeries/yr.), high-volume hospitals (≥75th percentile: ≥101 surgeries/yr.); (IX) Location and type of hospital as coded in the database into: metropolitan non-teaching, metropolitan teaching, non-metropolitan (12).

Statistical analysis

Statistical analysis used weighted data to reflect national estimates. The records' weights are available in the NRD and calculated based on the stratification variables that were used in the sampling methodology (12). Cross-tabulation and Chi-square test were used to examine the association between each of the independent factors and the risk of injury. Variables that demonstrated a significant association with the outcomes were considered possible confounders and were included in multivariate logistic regression models. Multivariate logistic regression models were used to estimate the risk of having the injury and the risk the study outcomes. Multivariate linear regression models were used to compare means of hospital length of stay and cost of health services between the study groups while controlling for confounders. Significance level was set as (α=0.05). All data analyses were performed using SAS 9.4 for Windows (SAS Institute Inc., Cary, NC, USA). The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Results

A total of 54,443 patients were included. Major structures injuries were reported in 189 (0.48%) patients (*Tables 1*,*2*). The injured structures were vascular (0.22%), lymphatic (0.18%), pharynx/esophagus (0.06%), neural (0.03%), and trachea/larynx (0.002%). The risk of injury increased annually during the study period [OR: 1.29, 95% CI: 1.16–1.44, P<0.001].

Patients who experienced major structures injuries tended to be older (≥55 years), with multiple comorbidities, and being treated in a teaching hospital, however, none of those factors was significantly associated with the risk of injury in the multivariate logistic regression model (*Table 3*). Two clinical factors were significantly associated with the risk of injury: diagnosis of head and neck cancer (OR: 1.80, 95% CI: 1.24–2.61, P=0.002) and neck dissection whether as the only procedure (OR: 7.02, 95% CI: 4.43–11.15, P<0.001) or in conjunction with a thyroid surgery (OR: 3.64, 95% CI: 2.11–6.30, P<0.001).

Patients with those injuries had a higher prevalence of blood transfusion (2.82% *vs.* 0.17%), postoperative fistula (3.10% *vs.* 0.03%), readmission (28.90% *vs.* 3.59%), and postoperative mortality (0.87% *vs.* 0.06%) (P<0.05 each) (*Table 4*). There was no reported mediastinitis in both cases and controls, and the risk of requiring tracheostomy and developing subcutaneous emphysema were not statistically significant (*Table 4*). Management of patients with those injuries was associated with a longer hospital stay by 4.86±0.48 days (P<0.001), and a higher cost by $16,151.00±173.36 (P<0.001).

Discussion

Over the last few decades, surgical checklists and protocols have been put in place to help reduce operative complications (15). In the present study, we found there is an upward trend in the risk of major structures injury in patients who underwent neck dissection, thyroid, and parathyroid surgeries. We have demonstrated that vascular, neural, and visceral injuries occur more often in cancer patients and when neck dissection is performed. We also found that these unfortunate incidents were associated with an increased risk of postoperative complications, blood transfusion, longer hospital stay, overall cost, readmission, and even mortality.

Neck dissection with or without thyroidectomy was strongly associated with the risk of a major structure injury compared to a parathyroidectomy, hemithyroidectomy or total thyroidectomy alone. There is a paucity of published data on the risk of iatrogenic intraoperative injuries during neck dissection versus a neck dissection with thyroidectomy. An analysis by Teymoortash *et al.* of 98 patients who had selective neck dissection, there were four incidents of internal jugular vein resection, and two incidents of

Table 1 Descriptive statistics of the study population, National Readmission Database, 2010–2015

	Sample population, (%) (N=54,443)	Intraoperative major structure injury (%)		
		Not reported (n=54,222)	Reported (n=221)	P[a]
Age (yr.)				0.39
18 – <45	26.45	26.48	20.76	
45 – <55	21.74	21.75	20.84	
55 – <65	23.16	23.14	26.61	
≥65	28.65	28.63	31.80	
Gender				<0.001
Male	27.11	26.96	58.87	
Female	72.89	73.04	41.13	
CCIS				<0.001
0	42.95	43.08	14.30	
1	34.84	34.85	32.07	
≥2	22.22	22.07	53.62	
Overweight				0.30
Not reported	87.58	87.59	84.82	
Reported	12.42	12.41	15.18	
Tobacco use history				0.024
Not reported	90.48	90.51	85.07	
Reported	9.52	9.49	14.93	
Diagnosis				<0.001
Cancer	28.31	28.15	60.82	
Benign	54.29	54.38	35.45	
Toxic thyroid disease	6.95	6.97	3.45	
Parathyroid disease	10.44	10.49	0.28	
Surgery				<0.001
Thyroid lobectomy	27.54	27.62	11.22	
Total thyroidectomy	36.94	37.06	12.73	
Parathyroidectomy	12.29	12.35	0.80	
Neck dissection	15.41	15.21	58.68	
Thyroidectomy and neck dissection	7.82	7.77	16.57	

[a], Chi-square test. CCIS, Charlson comorbidity index score.

lymphatic duct injury (16).

In this study, patients who had a major structure injury were more likely to have a longer hospital stay and be readmitted within 30 days of the procedure. An analysis of 990 patients after thyroid surgery in the NRD found calcium and mineral metabolism disorders to be the main reasons for readmission (17). These sequelae of complications can lead to a significant financial burden for the patient and hospital (18). New healthcare policies are emerging that place the increased costs associated with

Table 2 Descriptive statistics of the study population, National Readmission Database, 2010–2015

	Sample population, (%) (N=54,443)	Major structure injury (%)		
		Not reported (n=54,254)	Reported (n=189)	P[a]
Received blood transfusion				<0.001
Not reported	99.82	99.83	97.18	
Reported	0.18	0.17	2.82	
Required tracheostomy				<0.001
Not reported	99.13	99.15	93.07	
Reported	0.87	0.85	6.93	
Readmission within 30 days				<0.001
Not reported	96.30	96.41	71.10	
Reported	3.70	3.59	28.90	
Postoperative mediastinitis within 30 days				NA[b]
Not reported	100.00	100.00	100.00	
Reported	0.00	0.00	0.00	
Postoperative subcutaneous emphysema within 30 days				0.06
Not reported	99.95	99.96	99.74	
Reported	0.05	0.04	0.26	
Postoperative fistula within 30 days				<0.001
Not reported	99.95	99.97	96.90	
Reported	0.05	0.03	3.10	
Postoperative death within 30 days				<0.001
Not reported	99.93	99.94	99.13	
Reported	0.07	0.06	0.87	
Hospital volume (surgeries/yr.)				0.99
Low: 1–20	25.84	25.83	26.53	
Intermediate: 21–100	50.98	50.99	50.39	
High: ≥101	23.18	23.18	23.08	
Hospital type				<0.001
Metropolitan non-teaching	31.06	31.13	16.94	
Metropolitan teaching	63.36	63.29	78.70	
Non-metropolitan hospital	5.58	5.58	4.36	

[a], Chi-square test; [b], not applicable because there is no reported event.

complications on the hospital, physician, and acute care services (19).

In the present study, patients were more likely to need a blood transfusion, and the risk of additional procedures such as a tracheostomy tended to be higher. These secondary procedures, such as a blood transfusion, and postoperative complication can further complicate the recovery course and be life-threatening (20). The impact of major complications could extend beyond the immediate postoperative period. The current study does not have

Table 3 Risk of intraoperative major structure injury in patients underwent thyroid and neck head and neck surgeries in relation to clinical and demographic factors

	Risk of injury (%)	OR[a]	95% CI	P
Gender				
Male	1.03	1.75	1.23, 2.48	0.002
Female	0.27	Reference		
CCIS				
0	0.16	Reference		
1	0.44	0.98	0.61, 1.59	0.94
≥2	1.15	1.31	0.80, 2.16	0.28
Tobacco use history				
Not reported	0.45	Reference		
Reported	0.75	1.23	0.78, 1.94	0.36
Diagnosis				
Cancer	1.02	1.80	1.24, 2.61	0.002
Benign	0.31	Reference		
Toxic thyroid disease	0.24	1.61	0.79, 3.28	0.19
Parathyroid disease	0.01	0.118	0.01, 2.57	0.17
Surgery				
Thyroid lobectomy	0.19	1.36	0.76, 2.43	0.30
Total thyroidectomy	0.16	Reference		
Parathyroidectomy	0.03	0.76	0.10, 5.75	0.79
Neck dissection	1.81	7.02	4.43, 11.15	<0.001
Thyroidectomy and neck dissection	1.01	3.64	2.11, 6.30	<0.001
Hospital type				
Metropolitan non-teaching	0.26	Reference		
Metropolitan teaching	0.59	1.35	0.92, 2.00	0.13
Non-metropolitan hospital	0.37	1.50	0.68, 3.29	0.31

[a], the model includes all the factors listed in the table; [b], not applicable because no reported injury in patients with parathyroid disease. OR, adjusted odds ratio; CI, confidence interval; CCIS, Charlson comorbidity index score.

a long-term follow-up, however previous studies have demonstrated that injuries such as vocal cord paralysis and permanent hypoparathyroidism were associated with an increased risk of respiratory infection and mortality, respectively (21,22).

We found that major structure injuries tend to be higher in teaching hospitals, however this risk was not statistically significant. Large teaching hospitals more often treat patients with complicated presentation and past medical history, and perform complex and innovative procedures, with the involvement of education and participation of residents and fellows. Previous studies have examined surgical outcomes at teaching hospitals with mixed results (23-30). A study of 2,320,920 otolaryngology patients from the National Surgical Quality Improvement Program database found that resident involvement did not increase the risk of morbidity and mortality (23). Additionally, research has shown that complications are lessened

Table 4 Risk of selected postoperative outcomes based on whether the patient experienced intraoperative major structure injury

Outcome	Major structure injury	% outcome/ Mean (SEM)	OR[a]	95% CI	P
Blood transfusion	Not reported	0.17	Reference		
	Reported	2.82	4.11	1.57, 10.80	0.004
Required tracheostomy	Not reported	0.85	Reference		
	Reported	6.93	1.62	0.75, 3.53	0.22
Postoperative subcutaneous emphysema within 30 days	Not reported	0.04	Reference		
	Reported	0.26	2.66	0.30, 23.33	0.38
Postoperative fistula within 30 days	Not reported	0.03	Reference		
	Reported	3.10	34.29	5.96, 197.49	<0.001
Postoperative readmission within 30 days	Not reported	3.59	Reference		
	Reported	28.90	7.94	5.38, 11.70	<0.001
Postoperative death within 30 days	Not reported	0.06	Reference		
	Reported	0.87	4.70	1.07, 20.65	0.040
Length of stay (days)	Not reported	2.16 (0.01)			Reference[b]
	Reported	7.02 (0.48)			<0.001[b]
Cost ($)	Not reported	12,170.00 (28.71)			Reference[b]
	Reported	28,321.00 (176.18)			<0.001[b]

[a], logistic regression model includes: age (only tracheostomy model), gender (except emphysema model), Charlson comorbidity index score, weight status (only mortality, readmission models), tobacco use status (only readmission, tracheostomy, transfusion, mortality models), diagnosis (all models), type of surgery (all models), and hospital teaching type (tracheostomy, transfusion models); [b], linear regression model includes: age, gender, Charlson comorbidity index score, weight status, tobacco use status, diagnosis, type of surgery, hospital volume, and hospital teaching type. OR, adjusted odds ratio; CI, confidence interval; SEM, standard error of the mean.

when performed at high-volume centers and by high volume surgeons (8,30). Our findings are most probably a reflection that more complications occur at large teaching hospitals due to the increasing complexity of procedures that are performed at these institutions compared to non-metropolitan teaching hospitals.

This retrospective epidemiological analysis is not without inherent limitations. The analysis of the NRD database coding system is subject to misclassification errors. Causality cannot be inferred as the study is a retrospective cross-sectional analysis. Information in the NRD is collected from administrative data and does include extensive clinical details such as history of neck irradiation, neck dissection levels, staging, diagnostic studies, available resources, and reason for readmission. The NRD also lacks information regarding the severity of those injuries and what measures being implanted in their management. Nevertheless, the database is fit for a general epidemiological examination of the prevalence and outcomes of major structures injuries at the national level that no other resource could provide and could ultimately guide the direction of clinically-oriented studies. We believe that our data provides a epidemiological analysis of the prevalence, clinical burden, and financial burden of major structures injuries in head and neck surgery.

Conclusions

In patients undergoing thyroid, parathyroid, and neck dissection procedures, the risk of major structures injuries are considerable and appears to be annually increasing at the national level. Those injuries are more prevalent in

head and neck cancer patients, and during procedures that included a neck dissection. Those injuries are associated with a significant clinical and economic burden.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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