The hidden cost of deep neck space infections

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ABSTRACT

INTRODUCTION The incidence of deep neck space infection (DNSI) is rising and appears to be related to falling rates of tonsillectomy. The purpose of this study was to assess demographics of patients presenting with DNSI and the financial burden to the National Health Service (NHS).

METHODS Data were collected retrospectively on patients aged over 16 years admitted to NHS Greater Glasgow and Clyde with DNSI between 2012 and 2016. Demographics, aetiology and use of hospital resources were reviewed. The cost of hospital admissions was calculated using data from NHS Scotland's Information Services Division, the local diagnostics division and the *British National Formulary*.

RESULTS Seventy-four patients were admitted with DNSI during the study period. Forty (54%) were male. The mean age was 44.0 years (range: 16–86 years). The most frequent source of infection was the tonsil ($n=30$, 40.5%). The most common infective organism was *Streptococcus constellatus* ($n=9$, 12.2%). The mean length of stay was 11 days. Fifty-five patients (74.3%) required operative intervention. The mean cost of admission per patient was £5,700 (range: £332–£46,700).

CONCLUSIONS This study highlights the high cost burden of DNSI to the NHS. The incidence of DNSI in Glasgow has risen over the study period; contributing factors may include the reduced tonsillectomy rate and a reduction in antibiotic prescribing. As the incidence of DNSI continues to rise, there will be an increase in cost to the NHS, which must be planned for.

KEYWORDS

Tonsillectomy – Deep neck space infection – Parapharyngeal abscess – Retropharyngeal abscess – Neck abscess

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Deep neck space infections (DNSIs) are serious conditions caused by infection in the potential spaces in the neck.¹ Aetiological factors include tonsillitis, dental infections and salivary gland infections. Patient factors such as diabetes, corticosteroids and other forms of immunosuppression may contribute. DNSIs are known to have significant morbidity and mortality.¹ Mortality rates range from 1.6% to 7.6%.^{1–3} Complications include airway obstruction, mediastinitis and pneumonia. These can be devastating in a young cohort of patients.

DNSI is suspected based on clinical assessment. Computed tomography (CT) is the gold standard investigation.⁴ Some cases are treated with antibiotics alone but most require surgical intervention, including surgical treatment of the abscess but also life saving airway interventions such as intubation or tracheostomy. A significant proportion of patients must stay in either the intensive care unit (ICU) or the high dependency unit (HDU) with organ support and 'two-to-one' or 'one-to-one' nursing care.⁵ Owing to the risk of airway compromise, patients are often nursed in visible locations (ie 'airway rooms' present on some wards).

Evidence has highlighted the rise in DNSI in England and Wales over a period of 15–20 years^{6,7} despite the widespread availability of antibiotics. Unpublished Scottish data

examining admissions with 'sore throat' show a rise from 16 admissions with DNSI in 1996–1997 to 65 admissions in 2014–2015 (306% increase). This is hypothesised to be partly related to reduced tonsillectomy rates following adoption of the Scottish Intercollegiate Guidelines Network recommendations for tonsillectomy.⁷ NHS Scotland's Information Services Division (ISD) estimates the average cost of a day-case adult tonsillectomy to be £1,416.⁸

Other factors may include a decrease in antibiotic prescribing and an increase in virulence of causative organisms. In Scotland, the Scottish Reduction in Antimicrobial Prescribing (ScRAP) programme is an educational toolkit that was introduced in 2013 to reduce inappropriate antibiotic prescription in primary care.⁹

DNSIs have significant morbidity and mortality with an associated cost burden for the healthcare system. The aims of this study were to review the demographics of patients presenting with DNSI and to calculate the financial burden of DNSI to the National Health Service.

Methods

Ethical approval was not required for this study as it was a retrospective case sheet review. DNSI patients admitted

under the ear, nose and throat (ENT) or oral and maxillofacial surgery (OMFS) teams in NHS Greater Glasgow and Clyde between 2012 and 2016 were identified from clinical coding. Patients aged under 16 years were excluded from the study.

Demographic data, presenting symptoms and signs, the source and site of infection, treatment and investigations were recorded. Time spent in theatre was obtained where possible from the electronic theatre operating system to the nearest hour. Twenty patients had their operative time recorded.

Cost information for antibiotics was gained from the *British National Formulary*. Information on the cost of theatre time, ICU, HDU and ward bed days was supplied by the ISD.⁸ The costs of investigations including flexible nasendoscopy (FNE) were gathered from the local diagnostics division.

Descriptive statistical analysis was performed using Excel® (Microsoft, Redmond, WA, US). Spearman’s correlation co-efficient was used to determine the significance of any difference in frequency of presentation with DNSI over the study period. This was calculated using Prism® version 7 (GraphPad Software, La Jolla, CA, US).

Results

Seventy-four patients were admitted with DNSI during the study period. Forty (54%) were male. The mean age was 44.0 years (range: 16–86 years). Figure 1 shows the increase in presentation over the study period, which was statistically significant ($r=0.9735$, two-tailed $p=0.005$).

Patient factors

Forty patients (54.1%) were smokers. Thirty-eight (51.4%) had a positive alcohol history. Nine (12.1%) were immunocompromised. Four patients (5.4%) had diabetes mellitus, three (4.1%) were on immunosuppressants and two (2.7%) were taking long-term corticosteroids. On review of the electronic patient records, 14 patients (18.9%) had documentation of having attended their GP with tonsillitis in the past, with an average of 2 consultations per patient. Four patients (5.4%) had previously undergone tonsillectomy. Three (4.1%) had previously had tonsillitis warranting hospital admission.

Figure 1 Number of patients presenting with deep neck space infection

Twenty-four patients (32.4%) had visited their general practitioner (GP) or general dental practitioner (GDP) at least once and were discharged prior to appropriate referral to hospital. Of these patients, 17 (70.8%) received a course of antibiotics in the community before hospital admission. The mean duration of antibiotic treatment was 3.3 days (range: 1–5 days) prior to re-presentation to the GP/GDP and onward referral. Table 1 summarises the demographics of the admitted patients.

Admitting specialty and length of hospital stay

Forty-four patients (59.5%) were admitted under the ENT team and twenty-nine (39.2%) under the OMFS team. One patient (1.4%) was admitted under the rehabilitation medicine team because of a coexisting spinal injury; this followed a stay in critical care where the DNSI was managed by ENT doctors as visiting specialists.

The mean overall length of hospital stay was 11 days (standard deviation: 20 days). Twenty patients (27.0%) required admission to the ICU. The mean length of stay in the ICU was 2 days (range: 0–30 days). HDU admission was required by 21 patients (28.37%). The mean length of stay in the HDU was 1 day (range: 0–20 days). Sixteen patients (21.6%) had a stay in both the ICU and HDU.

Aetiology and presentation

The source of infection was the tonsil in 30 patients (40.5%), dental infection in 28 patients (37.8%) and salivary gland infection in 3 patients (4.1%). The aetiology was unknown in 11 cases (14.9%). The most common organism cultured was *Streptococcus constellatus* ($n=9$, 12.2%). This is outlined in Figure 2. Forty-four patients (59.4%) had bacterial growth on microbiological culture. In 55 cases (74.3%), a microbiological investigation was sent for culture. Of these, bacterial culture was achieved in 80% and six patients (13.6%) had antibiotic resistance. All of those with antibiotic resistance had sensitivities to another antibiotic.

The frequencies of different presenting symptoms and signs are shown in Figure 3. Centor clinical prediction scores (Table 2)¹⁰ were calculated on arrival at the hospital

Table 1 Patient demographics

Demographic	Number of patients (n=74)
Male	40 (54.1%)
Smoker	40 (54.1%)
Immunosuppressed	9 (12.1%)
Diabetic	4 (5.4%)
Previous tonsillectomy	4 (5.4%)
Previous admission with tonsillitis	3 (4.1%)
Visit to GP/GDP prior to admission	24 (32.4%)
Antibiotics prior to presentation	17 (22.9%)
GP = general practitioner; GDP = general dental practitioner

Figure 2 Causative organisms demonstrated on microbiological swabs. 'Other' includes *Candida albicans*, *Streptococcus salivarius*, *Mycobacterium tuberculosis*, *Staphylococcus epidermidis*, group C streptococci, *Streptococcus parasanguinis*, coliform bacilli and *Streptococcus pyogenes*.

Figure 3 The number of patients presenting with various symptoms and signs

for the 44 patients admitted under the ENT team. The mean Centor score was 2.4 (range: 1–4).

Site of infection

The site of infection was most commonly the parapharyngeal space ($n=45$, 60.8%). Twelve patients (16.2%) had infection in the retropharyngeal space while eight (10.8%) had infection in the submandibular space. In nine cases (12.6%), there were infections in multiple spaces.

Investigations

Fifty patients had FNE (67.5%). The mean number of FNE procedures performed was 1.72 (range: 1–10). Twenty-eight patients (37.8%) had chest radiography. The mean number of chest radiographs was 1.55 (range: 0–25). Fifty-seven patients (77.0%) had CT, with the mean number of CT scans being 1.61 (range: 0–17). Magnetic resonance imaging (MRI) was used for three patients (4.2%), with the mean number of MRI scans being 0.08 (range: 0–4).

A mean of 29.12 blood tests were performed per patient. The mean number of full blood count tests was 8.64 (range: 0–65), the mean number of biochemistry tests was 8.61 (range: 1–65) and the mean number of C-reactive protein tests was 8.24 (range: 1–54). A mean of 2.98 coagulation screen tests were performed per patient (range: 0–24). The mean number of 'group and save' tests was 0.84 (range: 0–11).

Treatment

Fifty-five patients (74.3%) required at least one operation. The mean number of operations was 1 (range: 0–10). Eleven patients (14.8%) needed more than one operation. The majority of operations ($n=43$) were incision and drainage with neck washout. Four tonsillectomies were carried out. Eleven cases (14.8%) required airway intervention in the form of tracheostomy; ten of these patients were decannulated. Nine patients were decannulated during their initial admission and one patient was readmitted for

Table 2 Centor clinical prediction criteria¹⁰

Criteria	Points	The likelihood of group A beta-haemolytic streptococcal infection increases with increasing score.
Tonsillar exudate	1	
Tender anterior cervical lymph nodes	1	
History of fever	1	
Absence of cough	1	

decannulation. The mean time to decannulation was 24.9 days (range: 3–93 days). The mean operative time was 69.3 minutes (for those with data available).

All patients received intravenous antibiotics. Sixty-nine (93.4%) received more than one type of antibiotic. The maximum number of different types of antibiotics received was five, in three patients (4.1%). The most commonly used antibiotic was metronidazole in 63 patients (85.1%), followed by benzylpenicillin in 39 patients (52.7%) and clindamycin in 30 patients (40.5%). Three patients required anticoagulation. The mean length of anticoagulant treatment was 120 days (range: 90–180 days). Forty-four patients (59.4%) were followed up in the clinic, with a mean number of appointments of 1.2 (range: 0–5). No patients had an underlying malignancy.

Complications

Complications (including tracheostomy) occurred in 15 patients (20.2%). There were two deaths (2.7%) but both patients had significant co-morbidities and one died during a prolonged admission from pneumonia after the DNSI had resolved. The frequency of the complications is summarised in Figure 4.

Cost of admission

The total cost of admission and treatment for all 74 patients was £421,795.89. The mean total cost per patient was £5,699.94 (range: £332.06–£46,700.24). A breakdown of the various costs is given in Table 3.

The mean cost of admission for our patients was extrapolated to include the rest of Scotland (307 patients admitted with DNSI between 2012 and 2016; personal communication from the ISD). This gives a total cost of £1,749,881.58 for that time period.

Discussion

This is the first study directly estimating the cost of inpatient treatment for DNSI, demonstrating its high cost burden. With a mean cost of admission of £5,700, this is higher than the average for tonsillectomy in Scotland (£1,416).⁸ The cost for patients with a difficult clinical course can be considerable, with a maximum of £46,700. The true cost is certainly higher as this study does not take into account GP visits, visits to the emergency department or follow-up clinic appointments.

Figure 4 Complications encountered among the 74 patients

Table 3 The individual costs of various aspects of hospital admission and the total costs for our cohort of patients

Item	Individual item cost	Total number	Total cost for all patients	Mean cost per patient
Intensive care bed day	£411	138	£56,733.00	£766.67
High dependency bed day	£212	75	£15,870.00	£214.46
Ward bed day	£268 (ENT, <i>n</i> =356), £462 (OMFS, <i>n</i> =185), £129 (rehabilitation, <i>n</i> =90)	631	£192,488.00	£2,601.19
Theatre cost per hour	£841 (ENT, <i>n</i> =62), £1,173 (OMFS, <i>n</i> =38)	100	£96,716.00	£1,306.97
Full blood count	£2.60	635	£1,651.00	£22.31
U&Es, LFT (biochemistry)	£6.80	633	£4,304.40	£58.17
C-reactive protein test	£0.68	606	£412.08	£5.57
Group and save test	£7.20	61	£439.20	£5.94
Coagulation screen test	£4.12	220	£906.40	£12.25
Chest radiography	£25	113	£2,825.00	£38.18
CT unit cost	£225	119	£26,775.00	£361.82
MRI unit cost	£430	6	£2,580.00	£34.86
Flexible nasendoscopy	£33	134	£4,422.00	£59.76
IV antibiotic dose	Variable (£1.60 for co-amoxiclav – £20.26 for meropenem)	2,448	£13,605.96	£183.86
Enoxaparin	£7.23 (treatment dose for 70kg patient)	95	£686.85	£9.28
Rivaroxaban	£1.80	265	£477.00	£6.45
Tracheostomy tubes*	£24.24–£86.46 (type dependent)	15	£964.00	£13.03
Total			£421,856.22	£5,700.76

ENT = ear, nose and throat; OMFS = oral and maxillofacial surgery; U&Es = urea and electrolytes; LFT = liver function test; CT = computed tomography; MRI = magnetic resonance imaging; IV = intravenous
 *Tracheostomy tube changes outwith our hospital are not included in this calculation. These figures are therefore an underestimation.

Cost analysis demonstrates that the primary expense in hospital admission is bed days in the ward environment. Theatre time was the second highest cost. This includes the combined cost of surgical and anaesthetic staff, and equipment. There was a surprising impact of intravenous antibiotic prescription, which varies depending on the organism, length of treatment and type of antibiotic used.

This study highlights the variability in the clinical course of DNSI. Although one patient was admitted for only an overnight stay, some admissions are prolonged with complications. Most patients require significant resource input. All of the patients in this study required antibiotic treatment, and over 70% required operative intervention and CT.

Centor *et al* have shown that both group A beta-haemolytic streptococcal infection and *Fusobacterium necrophorum* infection are more likely with higher Centor scores.¹¹ The mean Centor score on admission to ENT was 2.4. In the UK, the National Institute for Health and Care Excellence recommends that patients with a Centor score of >3 should receive antibiotics in primary care.¹² This suggests that it may not be obvious if patients are high risk, and highlights

the diagnostic difficulty that GPs and GDPs are often faced with when seeing patients in the early stages of a DNSI. In some countries across Europe, point-of-care C-reactive protein testing is used to guide antibiotic prescribing. This has been trialled in England, and was found to be cost effective as well as reducing inappropriate antibiotic prescriptions and infections.¹³

Comparisons with other studies

This study shows a fourfold rise in the number of patients presenting with DNSI, having increased from 0.55 per 100,000 population in 2012 to 2.45 per 100,000 in 2016. This trend is greater than the 41% increase reported in England over ten years⁷ although absolute rates of infection remain lower. Our study adds to the literature by looking at the characteristics of a UK population and is the only study looking at a Scottish population. Other authors have quoted a mean age of 49.5 years,³ which is in keeping with the findings of the present study.

The origin of infections differs from other retrospective reviews in that most (40.5%) are of tonsillar origin rather

than odontogenic.^{3,14} This higher incidence of infections of tonsillar origin has also been found in Brazil.¹ Prior to the availability of antibiotics, 70% of DNSIs were tonsillar in origin.⁴

Lau *et al* demonstrated a 310% rise in admissions with tonsillitis and a 31% rise in admissions with peritonsillar abscess in England between 1996 and 2011.⁷ Scottish data indicate a 143% increase in admissions with tonsillitis and a 116% increase in admissions with peritonsillar abscess between 1993–1994 and 2014–2015 as well as a 306% increase in admissions with DNSI between 1996–1997 and 2014–2015.⁸ This is in contrast to a 48% fall in tonsillectomy rates over the same period. Although this does not prove causation, it is interesting to note the proportion of cases in our cohort in which DNSI originated from the tonsil.

The operative intervention rate of 74.3% is comparable with that quoted by Huang *et al* of 72.5%.³ Our complication rate was 20.2%, in keeping with other quoted rates of 16.2–47.5%.^{1,3}

The most common causative organism in this cohort was *S. constellatus*. Studies from Brazil and Southern China have implicated viridans streptococci and *Klebsiella pneumoniae* as common organisms responsible for DNSI.^{1,2} This highlights the importance of local policy for antibiotic prescribing. Fortunately, antibiotic resistance was not high in our cohort (8.1%) and all of those with some antibiotic resistance had other sensitivities available. The cost of treating antibiotic resistant organisms can be considerable and this may be an issue in the future management of DNSI.¹⁵ However, prompt and appropriate administration of antibiotics may prevent a significant infection from developing.

The rise in incidence of DNSI in Scotland has occurred over a similar time period to the introduction of the ScRAP programme, which aims to reduce unnecessary antibiotic prescription in primary care.⁹ Although this does not prove a causal relation and there are likely to be multiple factors, the importance of antibiotic therapy in DNSI cannot be overstated.

Strengths of the study

These are the only Scottish DNSI data currently available. Ours is the first study to investigate the financial burden of DNSI. Data from the ISD were localised to our health board, allowing cost analysis of bed days and theatre time to be as accurate as possible. Similarly, costs of investigations were acquired from local departments to obtain accurate local figures.

Study limitations

Although the cost of hospital admissions for patients with DNSI has been crudely estimated, there is likely to be a wider economic impact on society. The majority of patients in our study were followed up and this cost has not been included. Some patients may have issues with returning to work. Furthermore, there is well documented evidence of

psychological issues in patients who have had a stay in the ICU.¹⁶

Conclusions

Even with advances in antibiotic treatment, DNSI continues to require operative intervention and leads to morbidity. This study shows that DNSI requires significant resources in terms of investigations, bed days, antibiotics and theatre time. Antibiotic resistance was not shown to be a concern in our patient group. However, this is a potential issue for the future. The difference in organisms from our cohort compared with others worldwide highlights the importance of local microbiological policy when treating DNSI.

The reported rise in DNSI is concerning because of the serious nature of these conditions and the high cost burden associated with their management. As the number of cases of DNSI increases, resources need to be available to treat these patients.

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