Iatrogenic nerve injury in a national no-fault compensation scheme: an observational cohort study

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SUMMARY

Background: Iatrogenic nerve injury causes distress and disability, and often leads to litigation. The scale and profile of these injuries has only been estimated from published case reports/series and analyses of medicolegal claims. Aim: To determine the current spectrum of iatrogenic nerve injury in New Zealand by analysing treatment injury claims accepted by a national no-fault compensation scheme. Methods: The Accident Compensation Corporation (ACC) provides national no-fault personal accident insurance cover, which extends to patients who have sustained a treatment injury from a registered healthcare professional. Nerve injury claims identified from 5227 treatment injury claims accepted by the ACC in 2009 were analysed. Results: From 327 claims, 292 (89.3%) documenting 313 iatrogenic nerve injuries contained sufficient information for analysis. Of these, 211 (67.4%) occurred in 11 surgical specialties, particularly orthopaedics and general surgery; the remainder involved phlebotomy services, anaesthesia and various medical specialties. The commonest causes of injury were malpositioning (n = 40), venepuncture (n = 26), intravenous cannulation (n = 21) and hip arthroplasty (n = 21). Most commonly injured were the median nerve and nerve roots (n = 32 each), brachial plexus (n = 26), and the ulnar nerve (n = 25). At least 34 (11.6%) patients were referred for surgical management of their nerve injury. Conclusions: Iatrogenic nerve injuries are not rare and occur in almost all branches of medicine, with malpositioning under general anaesthesia and venepuncture as leading causes. Some of these injuries are probably unavoidable, but greater awareness of which nerves are at risk and in what context should facilitate the development and/or wider implementation of preventive strategies.

Introduction

Inadvertent nerve injury complicating medical care causes distress and disability, and is a well known source of litigation (1,2). Data on the type and frequency of iatrogenic nerve injuries are limited to case reports (3,4), institutional case series (5,6), and analyses of medical negligence claims in tort-based medicolegal systems (7–9). These reports are subject to selection and publication bias. The true spectrum of these injuries remains unknown.

New Zealand has a population of about 4.4 million. Its national no-fault compensation scheme administered by the Accident Compensation Corporation (ACC), provides personal accident insurance which extends to patients who have sustained a treatment injury, namely a personal injury suffered when seeking or receiving treatment from a registered healthcare professional (10). Claims can be initiated by the patient, but are filed by a registered provider. Currently, around 9000 treatment injury claims are lodged each year, two-thirds of which are accepted for compensation. Between 2005 and 2010, nerve damage was the fourth commonest treatment injury, after wound infection, allergic reaction (excluding anaphylaxis) and haematoma/bruising, and accounted for 4.3% of all treatment injury claims (Tapp D. Personal communication). The aim of this study was to analyse accepted claims relating to iatrogenic nerve injury during one calendar year to determine the spectrum of these injuries in a national no-fault compensation scheme.

Methods

Treatment injury claims accepted by the New Zealand Accident Compensation Corporation between...
1st January and 31st December 2009 were analysed. Claim acceptance is based on specific inclusion criteria: a personal injury caused by treatment from one or more registered healthcare professionals and not a necessary part (such as excision of a nerve running through a malignant tumour), or ordinary consequence (such as cutaneous nerve damage from a correctly sited surgical incision) of treatment. Claims are excluded if the injury is caused by an underlying health condition, a resource allocation decision, or as a result of withheld, or delayed consent.

De-identified summary data for all treatment injury claims were reviewed by at least two investigators (AEM, JZ ± MDS) to identify those relating to primary nerve damage i.e. an injury occurring as a result of direct nerve damage. Claims related to secondary damage e.g. as a result of haematoma, radiotherapy, chemical burn, iatrogenic glaucoma, or the use of crutches, were excluded. Claims were not restricted to those where the primary injury was classified by ACC as ‘nerve damage’; any claim with a documented injury or symptoms indicating damage to a peripheral or cranial nerve, nerve plexus, or nerve root was included.

The complete record for each nerve injury claim was obtained from the ACC. Each claim file usually contained the following: completed injury claim forms (ACC45 and ACC2152), details of communications between the ACC and health care provider, internal and external medical advisor reports, specialist letters, operative notes (where applicable), and, in many cases, a neurology referral assessment.

Outcomes
The following anonymised data were extracted: age at injury; gender; self-reported ethnicity; injured nerve; signs and symptoms; mechanism of injury; setting [hospital (public/private, teaching, other), general practice, specialist rooms, dental practice and location (ward, operating theatre, other)]; practitioner [doctor (grade and specialty), nurse, dentist, phlebotomist etc.]; disability; and actual consequence for the client (Table 1).

To calculate approximate incidence figures for selected nerve injuries, denominator data for common surgical procedures performed in the public sector in New Zealand were obtained from the Ministry of Health using ICD-10 codes (11). Such procedures included hip and knee arthroplasty, disectomy, spinal decompression, knee arthroscopy, open hernia repair, thyroidectomy, varicose vein surgery and the total number of general anaesthetics. Surgical hospital activity data from every district health board in New Zealand were used to calculate the number of acute and elective patient discharges for orthopaedics (12). Both sets of denominator data were for the 2009 fiscal year (1 July 2009–30 June 2010).

The study was approved by the ACC Research Ethics Committee (ACC # 178) and by the Chairman of the University of Otago Human Ethics Committee (D10/046). The reporting of this study conforms where possible to the STROBE statement for observational studies (13). Confidence intervals were calculated using stata® 12.0 (StataCorp, College Station, TX, USA).

Results
The ACC decided 8776 treatment injury claims in 2009, 5227 of which were accepted (Figure 1). As of July 2010, 3012 treatment injury claims were declined, only 24 of which related to nerve damage; seven were deemed to be a ‘necessary’ part of treatment and 17 an ‘ordinary’ consequence of treatment. This report analyses 292 claims documenting 313 primary iatrogenic nerve injuries; 21 claims involved two separate nerve injuries. Most of these claims [252 (86.3%)] were lodged in 2009 (n = 171) or 2008 (n = 81).

Characteristics of claimants
Mean age of the 292 claimants, 57% of whom were female, was 48.5 ± 19.4 (range 0–88) years. Figure 2

| Table 1 | Accident Compensation Corporation definitions of grades for ‘actual consequence to client’ (ACC, New Zealand) |
|---|---|
| Minor | Minimal lessening of bodily function and which may require an increased level of care, review and evaluation, further investigation or referral to another clinician |
| Major | Short-to-medium lessening of bodily function unrelated to the natural course of the illness and differing from the expected outcome of patient management OR increased length of stay/surgical intervention required |
| Serious | An event, or related events, that has the potential to result in death or major permanent loss of function* |
| Sentinel | An event during care/treatment that resulted in unanticipated death/major permanent loss of function* |

*Not related to the natural course of the claimant’s illness or underlying condition.
shows the age distribution of claimants relative to the 2006 New Zealand population census data (14). The two most common ethnicities were European (79.5%) and Māori (6.2%).

**Injured nerves and associated procedures**

Peripheral nerves were damaged in 60.4% of claims, cranial nerves in 21.1%, nerve roots in 10.2% and nerve plexuses in 8.3%. The most commonly injured nerves, accounting for 72.8% of all nerve injuries, are shown in Table 2. The remaining 27.2% of nerve injuries involved 38 nerves, which individually accounted for no more than seven injuries each. Injuries to nerve roots and the median nerve each comprised one-fifth of all claims. Lumbar nerve roots were affected in 22 (69%) of 32 nerve root injuries and the fifth lumbar spinal nerve was the most commonly injured (n = 9), usually during spinal surgery. Subcutaneous nerves such as the ulnar, common fibular and superficial radial nerve featured prominently among claims.

There were 21 claims involving two nerve injuries: 13 bilateral nerve injuries (including five nerve roots damaged during spinal surgery and four ulnar nerve injuries from malpositioning), and eight claims documenting two separate nerve injuries (seven of which occurred during a single treatment event).

The specific treatment event associated with iatrogenic nerve injury was documented in 310 instances. In three claims, two possible mechanisms, a combination of nerve block and malpositioning in one, were implicated; as the predominant event associated with injury in these cases remains unknown, the denominator in Table 3 is 310. The 10 commonest procedures accounted for almost two-thirds of nerve injuries. Of the other 83 procedures, only parotidectomy, with or without neck dissection, individually accounted for more than 1% of injuries.

The most common procedure associated with iatrogenic nerve injury was malpositioning. Of these 40 claims, 36 occurred in the operating theatre (35 under general anaesthesia), three in the intensive care unit (under sedation and/or paralysis) and one on the ward. More than half [n = 22 (55%)] occurred in orthopaedics and general surgery, where the ulnar nerve and brachial plexus were most commonly affected. Overall, 11 of 26 iatrogenic brachial plexus injuries were related to excessive or prolonged abduction of the arm under general anaesthesia and 16 of 25 ulnar nerve injuries were caused by malpositioning. Neonatal Erb’s palsy accounted for another 11 brachial plexus injuries, although whether this is truly an iatrogenic injury is controversial (15). Venepuncture was the second commonest procedure involved in nerve injury; the median nerve was damaged in 18 of the 26 cases and the anterior interosseous nerve in two. Collectively, venepuncture and venous cannulation/catheterisation were associated with 52 (16.6%) injuries (those listed in Table 3 plus four central venous catheters, three of which were inserted peripherally). Hip arthroplasty was the leading orthopaedic procedure associated with iatrogenic nerve injury; among 19 total hip arthroplasties and two hemiarthroplasties, the sciatic nerve was most frequently damaged (n = 14).

**Context of injury: specialty and setting**

Two-thirds of iatrogenic nerve injuries (195 claims and 211 nerve injuries) were confined to 11 surgical procedures.

| Nerve                                      | n (%) |
|--------------------------------------------|-------|
| 1 = Median                                 | 32 (10.2) |
| 1 = Nerve root                             | 32 (10.2) |
| 2 Brachial plexus                          | 26 (8.3) |
| 3 Ulnar                                    | 25 (8.0) |
| 4 Common fibular                           | 21 (6.7) |
| 5 Sciatic                                  | 20 (6.4) |
| 6 Superficial radial nerve                  | 18 (5.8) |
| 7 = Inferior alveolar                      | 13 (4.2) |
| 7 = Recurrent laryngeal                    | 13 (4.2) |
| 8 Lateral cutaneous nerve of thigh         | 11 (3.5) |
| 9 Facial                                   | 9 (2.9)  |
| 10 Lingual                                 | 8 (2.6)  |
specialties: orthopaedics and general surgery together accounted for 42% of injuries (Table 4). The remaining third occurred within phlebotomy services, anaesthesia, dentistry and various medical specialties (see Table S1 for a detailed breakdown of nerve injuries and their context).

Of 313 nerve injuries, 252 (81%) occurred in a hospital setting, 58% of which were public hospitals. The remainder occurred in dental practices, specialist rooms, laboratories (phlebotomy services) and general practice. Overall, two-thirds of injuries \((n = 207)\) took place in an operating theatre, with an equal split between public and private hospitals. Of the 211 injuries related to surgical specialties, 189 (90%) occurred in an operating theatre whereas the others were recorded in wards, delivery suites, specialist rooms and the emergency department. Iatrogenic nerve injuries associated with venepuncture \((n = 26)\) occurred in laboratories \((n = 18)\), general practice \((n = 5)\) emergency rooms \((n = 2)\), and the ward \((n = 1)\).

Practitioners

Table 5 shows the range of practitioners involved in claims related to iatrogenic nerve injury; 164 (52%) were surgeons, mostly of consultant grade. Since a team of individuals consisting of anaesthetist, surgeon, operating theatre assistant and others are involved in malpositioning injuries in the operating theatre, the term ‘operating theatre staff’ was used to describe those involved in 38 such claims (36 definite malpositioning and two injuries where malpositioning and an additional mechanism were implicated). Five injuries involved two practitioners: either two surgeons \((n = 2)\) or an anaesthetist and midwife (a malpositioning injury) or an anaesthetist and operating theatre assistant (two cases with two possible mechanisms of nerve injury). Venepuncture associated nerve injuries were mostly associated with phlebotomists \((n = 19)\), but five such injuries were associated with nurses, and two with other health professionals.

Disability

The accident Compensation Corporation graded the actual consequence to each client as minor \((n = 175)\), major \((n = 135)\), serious \((n = 2)\) and sentinel \((n = 1)\). At least one-quarter of those aged between 15 and 64 years [55 (25.9%) of 212 claimants] were unable to resume work in the short-term after the injury. Pain and loss of sensation and/or mobility affected activi-
ties of daily living in almost all claimants, at least 34 (11.6%) of whom were referred for surgical management of their nerve injury. An example of a serious injury was a 59-year-old woman who underwent a discectomy for a prolapsed L3/4 intervertebral disc. She sustained damage to her L4 and L5 nerve roots bilaterally and to the cauda equina resulting in severe bilateral lower limb weakness, sensory loss and bladder and bowel disturbance. The true impact of injuries continues to unfold because, at the time of analysis, many cases were still awaiting referral or further treatment. Current compensation payments are not therefore a reliable reflection of total costs of the injury to the ACC, and have not been included.

**Denominator data**

Using the data in Table 6 listing publicly funded hospitalisations for surgical procedures in New Zealand between 1st July 2009 and 30th June 2010, approximate frequencies for some types of iatrogenic nerve injury can be calculated. These figures must be interpreted cautiously as the numerator relates only to ACC claims for treatment related nerve injury occurring in the public sector and accepted during 2009. The frequency of iatrogenic nerve injury from malpositioning under general anaesthesia can be estimated at 0.015%.

**Discussion**

This is the first attempt to describe the contemporary spectrum of iatrogenic nerve injury from a national perspective. These injuries were the fourth commonest cause of treatment injury claims accepted by the Accident Compensation Corporation’s national no-fault compensation scheme in New Zealand in 2009. They not only cause distress and disability but can result in long term morbidity. In common with other treatment injuries, they are likely to be associated with substantial costs to the healthcare system (16). Although some of these injuries may be unavoidable, it is likely that most are preventable. Before this is possible, it is essential to know which nerves are most at risk and in what context. The leading causes of iatrogenic nerve injury in this analysis were malpositioning under general anaesthesia, most commonly associated with brachial plexus and ulnar nerve injuries, and venepuncture, most often associated with median nerve injury. Two-thirds of all nerve injuries occurred within surgical specialties.

| **Table 5** Practitioners involved in iatrogenic nerve injury claims |
|-----------------------------|-----------------|----------------------|
| Practitioner                  | n = 318 | Grade (where applicable) | n |
| Surgeon                      | 164 (52) | Consultant | 151 |
| Registrar                    | 10      | Medical Officer | 1 |
| Medical Officer              | 1       | Unknown     | 2 |
| Operating theatre staff      | 38 (12) | Consultant  | 12 |
| Anaesthetist                 | 20 (6)  | Registrar   | 2 |
| Unknown                      | 6       |             |   |
| Dentist                      | 20 (6)  |             |   |
| Phlebotomist                 | 19 (6)  |             |   |
| General Practitioner         | 11 (3.5)|             |   |
| Other                        | 35 (11) |             |   |
| Unknown                      | 11 (3.5)|             |   |

| **Table 6** Estimated incidence of iatrogenic nerve injury in New Zealand |
|-----------------------------|-----------------|----------------------|
| Procedure                   | ACC accepted nerve injury claims (public sector only) (n) | Denominator (public sector) (n) | Estimated incidence (per 1000) | 95% CI |
| Total hip arthroplasty      | 11               | 4282                  | 3                              | 1.3–4.6 |
| Total knee arthroplasty     | 4                | 3506                  | 1                              | 0.3–2.9 |
| Spinal decompression        | 1                | 1036                  | 1                              | 0.02–5.4 |
| Discectomy                  | 5                | 811                   | 6                              | 2.0–14.4 |
| Spinal fusion + discectomy  | 1                | 128                   | 8                              | 0.2–43.5 |
| Orthopaedic surgical discharges | 42       | 62685                 | 0.7                            | 0.5–0.9 |
| Open inguinal hernia repair | 1                | 3314                  | 0.3                            | 0.008–1.7 |
| Thyroidectomy               | 4                | 1134                  | 4                              | 1.0–9.0 |
| Varicose vein surgery       | 1                | 785                   | 1                              | 0.03–7.1 |
| General anaesthetics        | 22*              | 147154†               | 0.1                            | 0.09–0.23 |

*Malpositioning related nerve injuries under general anaesthesia only.
†Refers to the number of surgical procedures performed under general anaesthesia and so the actual number of general anaesthetics is less.
There are specific lessons to be learned about which nerves are most at risk during particular procedures, especially in orthopaedics, which accounted for a half of all nerve injuries within surgery. Nevertheless, medical specialties are not exempt from these complications.

In the past two decades, there have been numerous large-scale studies and reviews of adverse clinical events in hospital and community patients (17–26) and the concomitant development of adverse event reporting systems (27) and patient safety organisations (28). To our knowledge, none of these studies or agencies has specifically investigated the problem of iatrogenic nerve injury. Our understanding of these injuries is largely restricted to case reports (29), institutional case series (5,6) and analyses of medical negligence or compensation claims (7,8) all of which are subject to selection and publication bias.

Anaesthesia related nerve injuries have been highlighted in several reports from the USA. In a retrospective analysis of 254,352 patients undergoing general anaesthesia during a 10-year period at the University of Michigan the estimated incidence of iatrogenic peripheral nerve injury was 0.037%; the proportion related to malpositioning was not stated (30). In our analysis, malpositioning under general anaesthesia was the single commonest cause of nerve injury, with an estimated incidence of 0.015% in the public sector in New Zealand. Consistent with the findings from medical claims analyses by the American Society of Anesthesiologists (ASA) (1) and the American Association of Nurse Anaesthetists (31), our study revealed that brachial plexus and ulnar nerve injuries are the commonest iatrogenic peripheral nerve injuries associated with anaesthesia. The problem of malpositioning under anaesthesia has recently led the ASA to publish evidence-based guidelines on appropriate patient positioning (32).

Historically, malpositioning injuries have often been attributed to the anaesthetist (33), but a more constructive approach is to consider appropriate patient positioning the responsibility of the whole operating theatre team. This is consistent with the modern focus on system errors and the importance of efficient team communication in the operating theatre in their avoidance (34,35). The development and implementation of the ‘Surgical Safety Checklist’ based on the World Health Organization (WHO) guidelines for safe surgery has highlighted the importance of a systematic approach to surgical care in the operating theatre and been shown to significantly reduce mortality and complications among surgical patients (35). The success of the 19-step checklist likely depends in part on its brevity, but appropriate patient positioning and protection of vulnerable nerves could be a useful addition. The WHO encourages institutions and organisations to tailor the checklist to local needs, and it is encouraging to note that a few checklists now include appropriate patient positioning (36). One such independent checklist, the Surgical Patient Safety System (SURPASS) developed in the Netherlands, is a multidisciplinary checklist which accompanies the patient through the surgical pathway (37). In this, one of the surgeon’s responsibilities is to check patient positioning. This relates particularly to pressure area protection, but probably also includes optimising surgical exposure and avoiding inappropriate positioning. It is surprising that this is not the joint responsibility of surgeon and anaesthetist, particularly as some surgical exposures demand a compromise between optimal and safe positioning. Implementation of the SURPASS checklist in six hospitals resulted in a significant decrease in nervous system complications from 2.1% to 1.2% (38), but it is unknown whether this included a reduction in malpositioning related iatrogenic nerve injuries. The use of speciality-specific incident reporting systems such as that developed by the collaboration between the Royal College of Anaesthetists and the National Patient Safety Agency in the UK (39) may be a useful method of monitoring iatrogenic nerve injuries related to general anaesthesia.

Venepuncture was the second commonest cause of iatrogenic nerve injury in our analysis. In isolation, these injuries are rare with estimates from blood donation centres ranging from 1 in 25,000 venepunctures (40) to 1 in 6300 (41). However, collectively they represent considerable morbidity. Injury to the superficial branch of the radial nerve which lies adjacent to the cephalic vein at the wrist is a well described complication of venepuncture and intravenous cannulation (42), prompting some authors to suggest that the cephalic vein in this region should not be used for venous access (43,44). The lateral cutaneous nerve of the forearm is at risk from venepuncture in the cubital fossa (45). Of more concern is damage to the median and anterior interosseous nerves, which accounted for 20 of 26 cases in our cohort. A few case reports have flagged anterior interosseous nerve injury complicating venepuncture (46), but few studies have investigated median nerve injury (47). Our findings suggest that iatrogenic nerve injury complicating venepuncture may be much more prevalent than commonly perceived.

Our study has some limitations. Since the change in ACC legislation in 2005 (48), a more open environment for reporting treatment injury has been fostered. There was initially a progressive increase in the number of claims each year, but this has since levelled out...
Iatrogenic nerve injuries in New Zealand

Abigail Moore: study design, analysis and interpretation of the data, drafting of the article, and final approval.
John Zhang: data collection and final approval.
Mark D Stringer: conception and design, interpretation of the data, critical revision of the article, and final approval.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Table S1. Detailed breakdown of 313 iatrogenic nerve injuries relating to 292 treatment injury claims accepted by the ACC, New Zealand in 2009.

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