Tertiary survey by trauma nurse specialist at a paediatric trauma centre

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ABSTRACT

INTRODUCTION: Tertiary surveys aim to detect injuries missed in the initial assessment of trauma. We introduced a process by which the trauma nurse specialist performed a number of the tertiary surveys (NTSs) at our paediatric trauma centre.

METHODS: Data from the first six months following introduction of the NTS were compared to retrospective data from the six months prior to NTS implementation (pre-NTS), when trauma surveys were completed by medical staff.

RESULTS: Over the 12-month period, 130 children met the criteria for a tertiary survey. Pre-NTS, 57/62 eligible patients received a tertiary survey, compared to 61/68 during NTS (p=0.77). There were significantly more road traffic crash patients in the NTS group (p=0.008) but no significant differences by demographics, injury pattern, injury severity score or outcomes. New injuries were found in three patients pre-NTS compared to five patients during NTS (odds ratio 1.3 (95%CI 1.3–2.0, p=0.73)).

CONCLUSION: This study conservatively supports the hypothesis that, with training and support, a trauma nurse specialist can perform tertiary surveys as effectively as doctors. A larger study is required to confirm these findings.

Trauma is a major health problem globally,\(^1,2\) with road injuries alone accounting for more deaths than any other cause among 10–19-year-olds and being the third most common cause of death among 5–9-year-olds.\(^3\) To optimise outcomes, trauma clinicians use primary surveys as a systematic means of rapidly assessing and treating life threatening injuries. Secondary surveys follow, which include a head-to-toe evaluation of the trauma patient, taking a complete history, performing a thorough clinical examination and revaluing the patients' vital signs to identify all other potentially significant injuries.\(^4\) The primary and secondary surveys can fail to detect some injuries that may adversely affect patient outcomes.\(^5-7\) The rate of undetected injuries during primary and secondary surveys in paediatric trauma ranges from 1–19%.\(^7-10\) Enderson et al first described the tertiary survey (TS) over 30 years ago.\(^11\) The TS focuses on detecting injuries missed by the primary and secondary surveys. A TS includes a complete review of all investigations and an additional comprehensive clinical examination by a member of the trauma team. The TS is usually performed within the first 24 hours after admission and has become a standard of care.\(^1\) Approximately 15–20% of injuries detected on the TS are clinically significant.\(^12\) Therefore, it is important that TSs are performed consistently and to an adequate standard.

Trauma nurse specialists have been involved in performing TSs since their inception.\(^11,13,14\) However, TSs are commonly seen as the domain of doctors.\(^15\) At some centres, including our own, doctors performing TSs can be quite junior and inexperienced, and they rotate on a regular basis, which leads to an ongoing need to train new staff. In addition, trauma patients are admitted under a range of specialties, such as orthopaedics, neurosurgery and general surgery, which may lead to variation in the quality of the TSs being performed.\(^15,16\) Allocating TSs to a permanent member of the trauma team, such as the trauma nurse specialist, has the potential to help maintain the quality of TSs.
The role of a trauma nurse specialist is to coordinate and monitor patients’ care and to link hospital resources. In their cohort study of 148 trauma patients, Curtis et al found that, when trauma cases were managed by experienced trauma nurses, the rate of undetected injuries at a major trauma centre reduced significantly; however, nurses did not perform the TSs in this study. In another, US study, where trauma nurse practitioners routinely performed the TSs, the authors reported that undetected injuries decreased and communication improved after they implemented a TS form. Resler et al reviewed TSs for previously undetected injuries at a US paediatric trauma centre and found a significant number of previously undetected injuries were detected when TSs were performed by nurse practitioners compared to TSs performed by residents.

We recently developed an education and implementation programme for nurse-performed tertiary surveys (NTS) at our paediatric trauma centre. This paper presents the results of a study comparing the rates of injuries detected by TSs before and after implementation of the NTS and describes the NTS implementation process. We hypothesised that the undetected injury rate would not change with NTSs.

Methods

The study took place at Starship Children’s Hospital (SCH), a tertiary paediatric hospital and major trauma centre that admits over 1,000 child trauma patients (0–15 years of age) annually from around New Zealand. All children eligible for a TS during the study dates (1 July 2018–30 June 2019) were included. There are no set criteria in the literature identifying TS eligibility.

Therefore, at SCH we developed our own criteria based on a review of the relevant literature regarding which patients were more likely to have an injury undetected from their primary or secondary survey. SCH patients who met one or more of these criteria were eligible for a TS (Figure 1):

- high-risk mechanism (pedestrian, passenger or cyclist involved in a road traffic crash, or fall >3 metres)
- meeting trauma call activation criteria
- admitted from another facility for definitive care.

We excluded patients who were admitted with non-accidental injury, minor penetrating injury or isolated injury (ie, those for whom the mechanism offered only a single point of impact that had already received full examination and imaging) and those who died in either the Children’s Emergency Department or Paediatric Intensive Care Unit. Our hospital does not admit major burns patients. For the purposes of this study, undetected injuries were those undetected on the primary or secondary surveys but detected on completion of the TS.

Nurse-performed tertiary survey development

Following a review of the relevant literature, existing TS guidelines and anecdotal evidence from the SCH trauma service regarding which patients are most likely to have injuries undetected on a primary or secondary survey, a revised TS guideline was developed. The key elements of the guideline included the pre-existing pathway for identifying patients eligible for TS (Figure 1) and a framework looking at all the components of the TS (Table 1). The framework, similar to that proposed by Janjua et al, included a complete physical examination and formal review of all blood

Table 1: Framework used during the nurse-performed tertiary survey process for completing a tertiary survey.

1. Review the clinical history.
2. Address clinical care components (eg, DVT prophylaxis, tetanus/immunisations, pain management, concussion screening).
3. Review radiology and laboratory results, ensure all reports are finalised and either repeat or discuss abnormal laboratory results with the admitting team.
4. Perform a physical examination; order plain radiology if clinically indicated.
5. Report and record the findings.
tests and radiology (ensuring all radiology has been formally reported by a consultant paediatric radiologist), a complete review of the history (in case any pertinent details may have been missed on initial presentation), a review of the care components relevant to trauma patients (such as venous thromboembolism (VTE) prophylaxis and vaccination status) and contingency processes put in place for reporting back any positive or contentious findings to both the trauma team and admitting service. Upon completion of the TS, all findings are recorded on a customised form (Figure 2). The draft guideline was presented to relevant key stakeholders in paediatric surgery, orthopaedics and neurosurgery, after which some minor adjustments were made and the guideline finalised.

The nurse specialist had previously learnt many of the clinical skills required for the head-to-toe examination from working as an emergency nurse specialist, such as abdominal and extremity assessment. They were taught other skills, such as cranial nerve assessment, prior to conducting the supervised TSs. After discussion with the medical team and on their agreement, the nurse specialist could order radiology investigations and blood tests and seek subspecialty consultation as appropriate, as adjuncts to the TS clinical examination. Verbal informed consent was gained from caregivers for all TSs performed by the nurse specialist during the training phase and the subsequent audit phase of the study. Patient assent was also sought on conscious, school-aged children. The nurse specialist observed two TSs being performed by the trauma director and two by a paediatric surgical registrar, each of which focused on good head, neck, chest, abdomen and extremity examination technique. Next the nurse specialist performed

Figure 1: Flow chart for tertiary trauma survey eligibility.
Figure 2: Starship Child Health trauma tertiary survey form.
a further 10 TSs on a range of eligible patients under medical supervision and received feedback on their performance and technique from the supervising doctor. No unanticipated performance issues were identified. The trauma director reviewed the TS findings. At the end of the supervision period the nurse specialist was deemed competent in the process and able to conduct TSs independently, being required to provide feedback on their findings to both the trauma director and the admitting team. The training took place over the six-month period 1 July 2018–31 December 2018, after which the NTS was formally implemented.

Data collection
Trauma survey results from the first six months of the NTS (1 January 2019–30 June 2019) were compared with data from the prior six-months’ training period. During the NTS period the nurse specialist and medical staff collaborated such that the nurse specialist performed most TSs during office hours and doctors performed TSs after hours and when the nurse specialist was not available. The aim was to determine whether there was any change in the rate that missed injuries were detected with NTS. Variables of interest included age, date of injury, date of admission, cause of injury, diagnosis, patient outcome, outcome of the TS and who performed the TS. These data were collected prospectively during the NTS period and obtained retrospectively for the training period (pre-NTS) from the Children’s Trauma Service Trauma Registry (Collector®, Digital Innovation, Forest Hill, MD, USA). The rate at which previously undetected injuries were detected was compared between the two six-month periods and between TSs performed by the nurse specialist and doctors.

Follow-up
All children admitted for trauma were followed-up in hospital by the nurse specialist until discharge. All patients who had NTSs were followed-up two weeks after discharge by a telehealth phone call, during which they were asked a variety of questions relating to any potential issues, such as pain, difficulty mobilising, cognitive impairment, excessive fatigue, anorexia, nausea and problems toileting, and the appropriate advice was given thereafter.

Statistical analysis
There are no existing quality standards for the NTS; however, given the range of undetected injuries in paediatric studies is 1–19%,7–10 we estimated that the TS should detect new injuries in about 5% of our patients. In a retrospective two-sample power analysis, sample sizes of 57 and 61 in each group gave a power of 0.77 at a significance level of 0.05 for a medium (0.5) Cohen conventional effect size.10

The primary outcome was the odds of detecting a previously undetected injury during the NTS period compared to the pre-NTS period. Categorical variables were compared by Fisher’s exact test. The distribution of continuous variables was inspected in frequency plots and tested by the Shapiro-Wilks test. Non-parametric data were compared using the Wilcoxon rank sum test. Multivariate analysis was performed using a generalised linear model with the detection of a new injury as the outcome and group (before or after implementation), age, gender and injury severity score as additional explanatory variables. Additional analysis was undertaken to compare TSs performed by the nurse specialist to TSs performed by a doctor. All statistics were run in the statistical programme R®.20,21

The study was registered with the institutional research office but was excluded as it was deemed a necessary business-as-usual activity.

Results
Over the 12-month period (1 July 2018–30 June 2019), 942 trauma patients were admitted, of whom 812 were excluded because of minor/isolated injury (n=703), non-accidental injury (n=13), minor penetrating injury (n=85), minor burns (n=5) or death (n=6).

The TS criteria were met by 130 patients, 68 of whom were assessed using the new NTS. These patients were compared with 62 patients who were assessed pre-NTS. Apart from more patients being injured in road traffic crashes during the NTS period, the two groups were similar in demographics, mechanism of injury, presence of head injury, and outcome (Table 2).
There was no significant difference in the proportion of eligible patients who received a TS between the NTS and pre-NTS groups. During the NTS period, seven eligible patients did not receive a TS, whereas five eligible patients did not receive a TS during the pre-NTS period (Table 2). Overall, 118 (91%) received a TS. The most common reason for not having a TS performed was admission and discharge over the weekend, when medical staffing levels were reduced and the nurse specialist was not available.

During the six-month period following the introduction of the NTS, 61 TSs were performed: 30 by the nurse specialist and 31 by a doctor. It felt important for the doctors to continue conducting some of the TSs during this time to promote and maintain their skills. In some cases (e.g., teenage female patients) it was more appropriate for a female doctor to do the TS rather than the male nurse specialist. New injuries were found in five of the 61 cases, of which the nurse specialist detected three and the doctor two. In the pre-NTS period, 57 TSs were conducted: 10 by the nurse specialist (under medical supervision as part of the nurse’s training in TSs) and 47 by a doctor, with new injuries detected in three patients (Table 3). Most of the injuries were orthopaedic, usually involving a distal upper limb or a digit and requiring immobilisation only. Examples of previously undetected injuries were finger fracture, ankle fracture, concussion and dental injuries. The distal limb injuries were detected in patients who were intubated and ventilated and for whom a period time had passed since their primary and secondary surveys. These newly detected injuries were assigned an appropriate abbreviated injury severity (AIS) code and injury severity score (ISS), adjusted accordingly. None of the new injuries picked up by NTS required surgery. Although painful and, in relation to the

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<tr>
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<th>Pre-NTS n=62</th>
<th>NTS n=68</th>
<th>P</th>
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<tbody>
<tr>
<td>Age in years</td>
<td>9 (5.25, 12)</td>
<td>8 (3.75, 12)</td>
<td>0.33</td>
</tr>
<tr>
<td>Female gender</td>
<td>19 (31%)</td>
<td>30 (44%)</td>
<td>0.15</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
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<tr>
<td>Māori</td>
<td>12 (19%)</td>
<td>14 (21%)</td>
<td>1</td>
</tr>
<tr>
<td>Pacífica</td>
<td>14 (23%)</td>
<td>12 (18%)</td>
<td>0.52</td>
</tr>
<tr>
<td>Other ethnicity</td>
<td>36 (58%)</td>
<td>42 (62%)</td>
<td>0.72</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Motor vehicle crash</td>
<td>9 (15%)</td>
<td>24 (35%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Pedestrian or driveway</td>
<td>17 (27%)</td>
<td>10 (15%)</td>
<td>0.32</td>
</tr>
<tr>
<td>Fall</td>
<td>14 (23%)</td>
<td>10 (15%)</td>
<td>0.27</td>
</tr>
<tr>
<td>Bicycle</td>
<td>9 (15%)</td>
<td>10 (15%)</td>
<td>1</td>
</tr>
<tr>
<td>Motorcycle, quad or</td>
<td>10 (16%)</td>
<td>5 (7%)</td>
<td>0.17</td>
</tr>
<tr>
<td>scooter</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Head injury</td>
<td>28 (45%)</td>
<td>33 (5%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Injury severity score</td>
<td>9 (5, 17.8)</td>
<td>9.5 (4, 21)</td>
<td>0.76</td>
</tr>
<tr>
<td>ISS</td>
<td>2 (1, 4)</td>
<td>3 (1, 7)</td>
<td>0.37</td>
</tr>
<tr>
<td>Received a tertiary survey</td>
<td>57 (92%)</td>
<td>61 (90%)</td>
<td>0.77</td>
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</table>

Categorical data as n (%). Continuous data as median [IQR].

Table 2: Characteristics of children eligible for a tertiary survey in the periods before and after the introduction of the nurse-performed tertiary survey (NTS).
concussion, impactful on the patient’s schooling, none of these previously undetected injuries were expected at discharge to affect the patients’ long-term outcomes. No further injuries were detected in any of the patients after completion of the NTS.

The odds of detecting a new injury were not significantly different on univariate analysis (p=0.72), or on multivariate analysis (OR 1.3, 95%CI -1.3–2.0, p=0.73), when the NTS and pre-NTS periods were compared. There was no significant difference in the odds of detecting a new injury during TS performed by the nurse specialist compared to TS performed by doctors (OR 2.1, 95%CI 0.44, 10, p=0.33).

Discussion

This study describes the process to implement an NTS in a paediatric trauma centre in New Zealand. The results showed that the nurse specialist was as effective as doctors at detecting previously undetected injuries in the TS. Importantly, our data show that neither the nurse specialist nor the doctor missed any injuries on completing the TS.

The present study is the first, to our knowledge, to describe a framework to train and support a nurse specialist in TSs. The framework included contingencies for any new injuries found on TSs. Trauma nurse specialists follow-up on aspects of clinical care as part of their regular duties. This includes ensuring radiology is formally reported and that abnormal lab test results are highlighted to the clinical teams and acted upon accordingly. The present study shows that up-skilling an experienced trauma nurse to perform TSs is a viable option; however, we feel it is important that TSs are not exclusively done by nurses, since TSs are an important part of training of junior doctors in trauma.

Our results are consistent with Resler et al, who showed an increase in the rate at which previously undetected injuries were detected with the introduction of nurse-practitioner performed TSs at a children’s trauma centre. The rate at which previously undetected injuries were detected in the present study was in keeping with detection rates of 1–19% seen in other studies in which TSs were performed by medical staff. Further research on NTSs in smaller trauma units or in hospitals that treat both adults and children could help confirm the generalisability of our results to other settings.

Adopting the NTS process has eased the workload on junior doctors at our institution, allowing them to carry out other aspects of their role while enabling the nurse specialist to further develop and enhance their skill set without compromising the safety of the patient. This synergistic effect with medical staff was also noted by Huynh et al, who found that TSs performed by non-physician practitioners

<table>
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<th>Table 3: Allocation of the tertiary surveys and new injury detection rates before and after the introduction of the nurse-performed tertiary survey (NTS).</th>
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<tbody>
<tr>
<td>Before NTS introduced n=57</td>
</tr>
<tr>
<td>Trauma nurse specialist</td>
</tr>
<tr>
<td>Cases with new injuries</td>
</tr>
<tr>
<td>Doctor</td>
</tr>
<tr>
<td>Cases with new injuries</td>
</tr>
<tr>
<td>Total cases with new injuries detected</td>
</tr>
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* Before NTSs were introduced, 10 of the 57 tertiary surveys were performed with the doctor supervising the trauma nurse specialist.
reduced residents’ workloads and improved processes.24

Undetected injuries represent a clinical risk in trauma care. NTSs transfer the responsibility for detecting previously undetected injuries from doctors to the trauma nurse; however, the trauma director remains ultimately responsible. Trauma directors must ensure that their staff are properly trained and supervised. In our service, the nurse specialist already had many years’ experience as a nurse specialist in paediatric trauma and the emergency department and had an established skill set in clinical history taking and examination. We also have a supportive team of surgeons in training and junior doctors who are readily available for support. In New Zealand, nurse specialists work collaboratively within a specialty team. They may have delegated medical responsibilities, undertake diagnostics, implement treatment protocols and prescribe according to standing orders.25 Therefore, a nurse specialist working within an established trauma service seems a good model for NTSs. A nurse practitioner role, with the ability to take on full clinical responsibility, would also suit the position.

Limitations

This study was limited by its small sample size and the retrospective control group. The study was not adequately powered to detect a medium difference in the detection rate of new injuries. A larger prospective study is required to confirm our findings. Such a study could be designed to have both a doctor and the trauma nurse perform TSs on the same patient and compare the results for inter-rater reliability and accuracy. Alternatively, patients could be randomised to either the nurse specialist or doctor to perform their TS. In addition, a study conducted over at least 12 months would account for seasonal variability commonly seen in trauma care. Interventions and outcomes were conducted by the same investigator, which poses a risk of bias. One trained and experienced nurse specialist but several different doctors performed the TSs, which might limit the generalisability of our findings. The nurse specialist performed the TS during office hours, whereas the junior medical staff could have been performing TSs after hours during a long weekend shift, which could impact on clinical assessment. The nurse specialist already had a pre-existing skill set that enabled this process to begin, whereas others new to the role would require further training. The nurse specialist performed some TSs during the ‘control’ period, which we addressed in the additional analysis. We have not evaluated the cost and time implications of NTSs, which should be considered in future studies. The follow-up at two weeks was the only follow-up and was conducted by phone call, not in clinic, so an injury undetected during the TS might possibly have been missed at follow-up. Future studies should pay close attention to follow-up to ensure their denominator of missed injuries is accurate. Nine percent of eligible patients failed to receive a TS in our study. This calls for a quality improvement initiative and should be addressed in future research.

Conclusions

This observational study suggests that trauma tertiary surveys may be undertaken by an experienced trauma nurse after a structured training programme and with ongoing supervision and support. To validate these findings, a larger, prospective study is required.
Competing interests:
Nil.

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