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Concussion assessment in the emergency department: a preliminary study for a quality improvement project

Dylan A Mistry,[1] Timothy H Rainer[2]

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[1]School of Medicine, Cardiff University, Cardiff, UK
[2]Division of Population Medicine, School of Medicine, University Hospital of Wales, Cardiff University, Cardiff, UK

Correspondence to
Dr Timothy H Rainer; thrainer@cuhk.edu.hk

ABSTRACT

Background In sport, concussion is assessed using the Sports Concussion Assessment Tool (SCAT) 5 and managed with return to play guidelines. Similar, user-friendly tools are rarely, if ever, used in the emergency department (ED).

Objectives To evaluate a modified concussion assessment tool designed for the ED (ED-CAT) in patients presenting with a head injury and to identify variables that predict 30-day reattendance.

Methods A preliminary, prospective, evaluation in a quality improvement project was conducted in one hospital in South Wales. Patients were recruited if they were over 13 years, and either did not have an ED-CT head scan or had a scan with no acute changes. The primary outcome was 30-day reattendance.

Results 40 patients were recruited, 18 of whom had a CT scan. 37 were discharged on the same day with advice, two discharged the next day and one was admitted. Three (7.5%) patients reattended the department. Predictors of reattendance were headache score (median 3.0 vs 5.0; p<0.05), pressure in head score (2.0 vs 5.0; p<0.05), nausea/vomiting score (1.0 vs 3.0; p<0.05), dizziness score (1.0 vs 4.0; p<0.05), blurred vision score (0 vs 4.0; p<0.01), balance problems score (0 vs 4.0; p<0.05), sensitivity to light and confusion score (0 vs 4.0; p<0.01), orientation score (1. 0 vs 0; p<0.05) and immediate memory score (5.0 vs 4.0; p<0.05).

Conclusions Key symptoms and signs predicted 30-day reattendance. The ED-CAT requires validation and refinement in a larger population to produce a short, practical, user-friendly, relevant tool for ED head injury assessment.

What are the new findings?

- A tool designed for concussion assessment within the emergency department (ED) was able to be developed by modifying the Sports Concussion Assessment Tool 5.
- Key symptoms and traits on the tool were able to identify reattenders to the ED.

How might it impact on clinical practice in the near future

- With further development, this tool may be used in the ED to identify those suffering a more severe concussive episode.

INTRODUCTION

Concussion is one of the complications of a head injury, a common presentation to the emergency department (ED).[1] Evidence in the UK is lacking, but the presentations of concussion to the ED in America has been estimated to be over 150 000 annually.[2] Another study reports that around 100 000 patients per year present to the ED in just the 8–19 age group in America.[3] In sport, where there is more evidence, incidence is highest in rugby and ice hockey.[4]

The operational definition of concussion as the 'immediate and transient symptoms of mild traumatic brain injury' but this has drawn criticism due to a lack of accuracy.[5] The Concussion in Sport Group (CISG)[6] defines concussion as a 'complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces'. This may be due to a blow to the head or body that leads to the rapid development of neurological impairment that does not last long and resolves of its own accord.[6] The acute symptoms are less likely to be due to structural injury and therefore are associated with grossly normal neuroimaging. However, concussion may cause neuropathological changes.[6] The clinical and cognitive symptoms (of which loss of consciousness may be included) of concussion and its sequelae typically resolve gradually.[6] The initial effects of concussion cover a large spectrum of symptoms.[7] The CISG[7] list these over certain 'clinical domains'. These include somatic/cognitive/emotional symptoms, physical signs such as loss of consciousness, balance impairment, behavioural changes, cognitive impairment and sleep/wake disturbance.[7] The CISG advise that concussion should be suspected if any of the symptoms are present, but acknowledge that they are non-specific.[7]

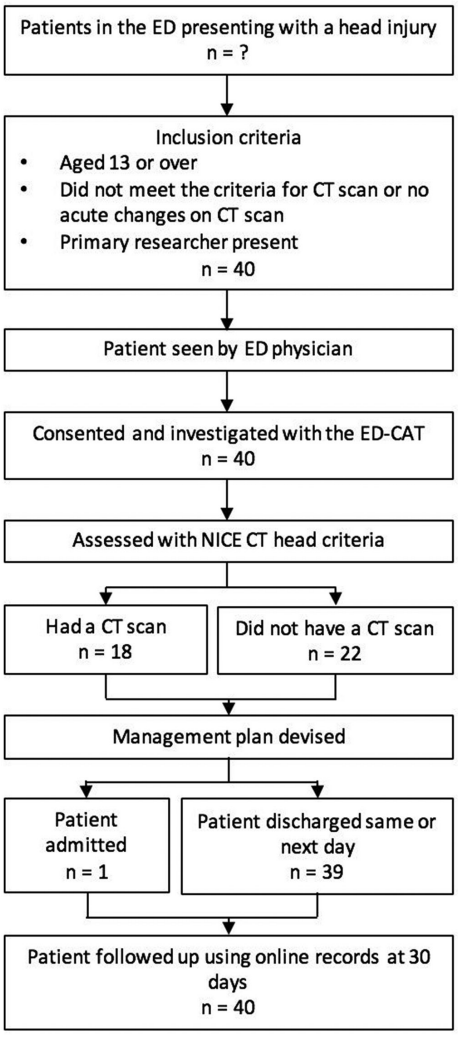

Figure 1 Flow chart showing the methodology of the study.

In sport, concussion is routinely assessed using the Sports Concussion Assessment Tool (SCAT) 5[8] which has been adopted by many sporting bodies.[9] The SCAT requires a clinical judgement to be made by the examining clinician based on the scores from each section of the assessment; it does not simply identify those who are concussed.[9] Recommendations for sports-related concussion management have been summarised by the CISG in the graduated Return to Play guidelines (see online supplementary appendix 2).[7]

The National Institute of Clinical Excellence (NICE)[10] in 2014 published detailed recommendations for patients presenting to the ED with a head injury. However, concussion receives little attention. The main assessment in the ED is to identify if the patient needs a CT head scan according to the Canadian CT head rule.[11] There is no routinely used, formal assessment for concussion. The mainstay of management for concussion is discharge with advice regarding red flag symptoms, head injury leaflets and no follow-up.[12 13] Concussion advice in the ED is minimal compared with Return to Play guidance for athletes.[7] This may partly be due to time pressure and partly due to prioritisation perspective, as the priority for ED is to rule out life-threatening events.[13]

It is important not to miss concussion. Athletes who have had a concussive episode are at higher risk of re-injury, further concussive episodes in the same season,[14] second impact syndrome, postconcussion syndrome and long-term neuropsychological effects.[15] Repeated concussions can lead to neurodegenerative changes, a disease process known as chronic traumatic encephalopathy.[16 17] Those that return to normal activities too early are at risk of these complications.[15]

There is little evidence about concussion in the general public or in recreational sport, which also means it is often poorly managed in these populations.[18] Data collection systems need improving in the community and in the ED.[19] This could be achieved by introducing the SCAT into the ED as an adjunct to the clinical diagnosis of concussion.[12 20] However, the SCAT is long and cumbersome and unlikely to be adopted in busy EDs. However, a shorter, simpler, evidence-based assessment tool could be adopted.

There is currently no generally well-accepted, objective tool for recognising concussion in the ED. Tools have been developed, such as the Acute Concussion Evaluation form,[21] but these have not been adopted in the ED setting. The objectives of this study, in patients presenting to the ED with a head injury, are to evaluate a potential ED concussion assessment tool investigating which variables predicted 30-day reattendance. This tool may help identify those patients with a more severe concussion who may benefit from follow-up

METHODS

Design, setting and participants

As part of a quality improvement programme to improve head injury and concussion assessment in the ED, we have conducted a preliminary, prospective, single-centre study to assess concussion in the ED. Participants were recruited if presenting to the ED of a major teaching hospital in South Wales with a head injury from 25th November 2017 to 22nd January 2018. To be recruited, patients had to present between 08:00 and 17:00 Monday–Friday, when the primary researcher was present. Patients were eligible if aged ≥13 years and either not requiring a CT head scan or with a negative CT scan. Patients were excluded if they had acute changes on CT scan. The methodology of the study is demonstrated in figure 1. The model and cycle specific for this project is shown in online supplementary appendix 4.

The assessment tool and data collection

The SCAT5 form was modified in order to produce a suitable form for use in the ED—the Emergency Department Concussion Assessment Tool (ED-CAT; see online supplementary appendix 3). The sections used for immediate/on field assessment from SCAT5 were removed and some sections were shortened. It still retains several sections, which include patient details, orientation, immediate

Table 1 Summary of each section of the Emergency Department Concussion Assessment Tool

Section	Name	Summary	Maximum score	How scoring works
1	Patient details/ background	Identifies cause, time and date of injury and any risk factors for delayed recovery such as previous concussions.	–	–
2	Orientation	Assesses patients' orientation to time and date. One point given for each correct answer.	5	Higher score indicates better orientation.
3	Immediate memory	Asks patient to remember and say five words, which are read out to them three times. One point given for each word remembered.	15	Higher score indicates better memory.
4	Symptom screen	Assesses number of symptoms and severity of each symptom experienced, out of 6, by the patient and if these are worse during physical or mental activity.	Number of symptoms=22. Symptom severity score=132.	Higher score indicates more severe symptoms.
5	Balance examination	Assesses patients' ability to stand on both feet, on just their weaker foot and in a tandem stance with their eyes closed and hands on hips for 10 s, as well as performing tandem gait over 3 m. Patients given a score out of 10 for each exercise and docked a point for each error made.	40	Higher score indicates better balance.
6	Delayed recall	Asks patient to recall the five words repeated to them during the immediate memory section. One point given for each word remembered.	5	Higher score indicates better memory.

memory, symptom screen, balance examination and delayed recall. The SCAT5 is restricted to those over the age of 13, hence why the age cut-off for this study was the same. A summary of each section can be found in table 1.

After the patients were clerked and assessed by an emergency physician, they were verbally consented for the study and assessed using the ED-CAT. The original attending emergency physician then made decisions about whether the patient required a CT scan and about further management. Patients were encouraged to return to the ED if symptoms had not resolved in 3–4 weeks.

Outcomes and follow up

The primary outcome for this study was 30-day reattendance to the ED. This was achieved by scanning the online patient records. Correlations were also analysed between the ED-CAT scores and likelihood of requiring a CT scan.

Statistical analysis

The data collected was analysed using the Mann-Whitney U test, a univariate non-parametric analysis. IBM SPSS Statistics (IBM Corp. Released 2015. IBM SPSS Statistics for Mac, V.23.0. Armonk, New York: IBM Corp.) and MedCalc (MedCalc Software, V.15.8, Ostend, Belgium) were used.

RESULTS

A total of 40 patients were recruited for the study. All 40 were followed up using online patient records. Patient flow through the study is demonstrated in figure 1.

Baseline characteristics, scores on ED-CAT and hospital management

The baseline characteristics of all 40 participants are shown in table 2, as well as the total scores for each section on the ED-CAT form.

Primary outcome—30-day reattendance

Of the 40 patients, three (7.5%) reattended the ED within 30 days of their initial assessment. Two patients reattended once and one reattended twice. This patient first reattended the same day due to vomiting and returned 28 days later due to dizziness. The reason for the other two participants reattending was because of worsening symptoms and the other started to develop dysphagia and right lower limb paresis and paraesthesia. This patient did not have a CT head scan initially but did so on their second attendance (as well as a CT cervical spine scan) but it showed no acute changes. They were admitted to hospital for 7 days before their symptoms cleared and they were discharged with concussive trauma.

Participant demographics, total scores for each section on the ED-CAT and management in the ED is shown in table 3 and the individual breakdown of each section on the ED-CAT is shown in table 4, compared with whether they reattended within 30 days.

The sections on the ED-CAT, which showed a significant difference in medians between reattenders and non-reattenders, were the orientation total score (step 2), orientation to date and time, one of the immediate memory trials, eight of the 22 symptoms and the sum of symptoms severity in step 4. The eight symptoms were headache, pressure in head, nausea or vomiting,

Table 2 Participant's characteristics*

Variable	Participants (n=40)
Age, mean (SD), years	45.23 (24.97)
Male	19 (47.5)
Time between injury and assessment in hospital, mean (SD), hours	45.15 (121.70)
Sports-related head injuries	5 (12.5)
Number of previous concussion, mean (SD)	0.35 (0.74)
Hospitalised because of HI in the past	6 (15.0)
Diagnosed or treated for headache disorder or migraines	11 (27.5)
Diagnosed with learning disabilities or dyslexia	2 (5.0)
Diagnosed with ADHD	0 (0.0)
Diagnosed with depression, anxiety or sleep disorder	8 (20.0)
Currently prescribed medication	24 (60.0)
Cause of HI	
Direct blow	18 (45.0)
Fall	19 (47.5)
Motor vehicle collision	3 (7.5)
Step 2 score: orientation (0–5), mean (SD)	4.65 (0.62)
Step 3 score: immediate memory (0–15), mean (SD)	13.58 (2.06)
Step 4 score: total number of symptoms (0–22), mean (SD)	11.13 (6.60)
Step 4 score: symptom severity score (0–132), mean (SD)	35.93 (28.12)
Symptoms worse with physical activity	
Yes	5 (12.5)
No	7 (17.5)
Unknown	28 (70.0)
Symptoms worse with mental activity	
Yes	19 (47.5)
No	12 (30.0)
Unknown	9 (22.5)
Step 5 score: balance examination (0–40), mean (SD)	24.18 (15.18)
Step 6 score: delayed recall (0–5), mean (SD)	3.03 (1.70)
Investigated with a CT scan in ED	18 (45.0)
Management of patient	
Discharged home same day	37 (92.5)
Discharged home next day	2 (5.0)
Admitted	1 (2.5)
Patients reattending the ED within 30 days	3 (7.5)

*Values are number (%) of participants unless stated otherwise. If a mean is shown, in brackets is the SD. In brackets after variables that are scored are the potential scores available for that section.
ADHD, attention deficient hyperactivity disorder; ED, emergency department; HI, head injury.

dizziness, blurred vision, balance problems, sensitivity to light and confusion.

Correlations between variables—ED-CAT scores and CT scan

Of the 40 patients, 18 were investigated with a CT scan in the ED as per the NICE criteria, none of which had acute changes. When comparing total scores on each section of the ED-CAT and whether or not the patient had the scan showed only one significant result, the balance examination score (step 5). This showed that those who met the criteria scored significantly lower and therefore demonstrated worse balance (median scores of 14.00 vs 35.00).

Management in the ED

Thirty-seven patients were discharged from the ED the same day with head injury advice and a leaflet. Two patients were discharged the next day from the ED. One patient was admitted for 2 weeks due to frailty. Six patients were unable to perform the balance examinations (step 5), either due to unsteadiness or dizziness, and one patient had sustained an undisplaced ankle fracture as well as a head injury in a motor vehicle collision. These patients scored 0 on the balance examinations as a result.

DISCUSSION

This prospective preliminary quality improvement project is one of the first studies looking into concussion assessment in an ED setting using an appropriate tool (the ED-CAT) modified from the SCAT5. This study has demonstrated that scores on certain sections of the ED-CAT were more likely to correlate to a reattendance to the department within 30 days of the original presentation. This may suggest that the concussion experienced by these patients was more severe.

Quality improvement projects are continuously improving processes used to achieve high quality care.[22] They involve several elements which are summarised by the model of improvement and plan, do, study, act cycle. They tend to be more effective than traditional audits as a series of interventions and adaptations can be assessed quickly. This project is the first initiative in the quality improvement process aiming to improve concussion assessment in the ED. The cycle (see online supplementary appendix 4) allows for further improvement to be made specifically, to validate the form and test the form using other clinical outcomes (figure 2).

The ED-CAT is one of the first forms to aid the assessment of concussion in the ED. It does not include the immediate acute tests that are present in the SCAT5 such as the 'on field assessment'. This makes it suitable to use when patients have self-presented to an ED sometime after their original injury. Some sections of the SCAT5 were shortened, so that ED-CAT was suitable to use in a busy ED where assessing patients efficiently and safely discharging them is critical. The ED-CAT consists of five scoring sections which are orientation, immediate memory, symptom screen (which is split into number of

Table 3 Summary of patient demographics, scores on Emergency Department Concussion Assessment Tool and management in the emergency department*

Variable	Reattended (n=3)	No reattendance (n=37)	P value
Age, median (IQR), years	53	36.00 (23.75–68.00)	0.6812
Male	2 (66.7)	17 (45.9)	–
Time between injury and assessment, median (IQR), hours	15.83	15.50 (3.50–37.54)	0.719
Sports-related HIs	0 (0.0)	5 (13.5)	–
Number of previous concussions, median (IQR)	0	0.00 (0.00–0.50)	1
Hospitalised for a HI in the past	0 (0.0)	6 (16.2)	–
Diagnosed or treated for headache disorder or migraines	1 (33.3)	10 (27.0)	–
Diagnosed with learning disabilities or dyslexia	0 (0.0)	2 (5.4)	–
Diagnosed with ADHD	0 (0.0)	0 (0.0)	–
Diagnosed with depression, anxiety or sleep disorder	0 (0.0)	8 (21.6)	–
Currently prescribed medication	2 (66.7)	22 (59.5)	–
Cause			
Direct blow	1 (33.3)	17 (45.9)	–
Fall	1 (33.3)	18 (48.6)	
Motor vehicle collision	1 (33.3)	2 (5.4)	
Step 2 score—orientation (0–5), median (IQR)	3	5.00 (4.75–5.00)	0.0451
Step 3 score—immediate memory (0–15), median (IQR)	13	14.00 (13.00–15.00)	0.365
Step 4 score—number of symptoms (0–22), median (IQR)	17	9.00 (4.50–16.50)	0.142
Step 4 score—symptom severity (0–132), median (IQR)	67	26.00 (9.75–51.00)	0.04
Step 5 score—balance examinations (0–40), median (IQR)	0	31.00 (10.00–37.50)	0.328
Step 6 score—delayed recall (0–5), median (IQR)	2	3.00 (2.00–4.50)	0.559
Investigated with a CT head scan	2 (66.7)	16 (43.2)	–
Management			
Discharged home same day	3 (100)	34 (91.9)	–
Discharged home next day	0 (0)	2 (5.4)	
Admitted	0 (0)	1 (2.7)	

*Values shown is number (%) of participants unless stated otherwise. If a median is shown, in brackets is the IQR. No IQR could be generated for reattenders as the sample was too small. In brackets after variables that are scored are the potential scores available for that section.
ADHD, attention deficit hypersensitivity disorder; HI, head injury.

symptoms and symptoms severity score), balance examination and delayed recall. As each section is scored differently (which may cause some confusion), the tool cannot produce a total score to sum up how the patient performed on the assessment. The orientation, immediate memory, balance examination and delayed recall sections are scored such that a higher score means the patient has performed better on this section. Whereas for the number of symptoms and symptom severity scores, a higher score indicates worse symptoms. The scores should be considered together as part of the overall clinical picture (as is advised by the CISG when using the SCAT5[9]). It must be noted that the balance examination was changed from the modified Balance Error Scoring System (mBESS) on the SCAT5 from 20 s to 10 s and the scoring system was reversed. This is not validated; however, the SCAT5's methodology and scoring system is. It is recommended for future studies to revert back to modified BESS employed by the SCAT5.

Our study has showed that the orientation score, symptom severity score and parts of the symptom and immediate memory sections were able to predict worse outcomes. Patients who reattended the ED within 30 days were significantly more likely to have worse orientation overall as well as worse scores for orientation to date and time; remember less words on the third trial of the immediate memory test (4 words vs 5); be experiencing more severe symptoms of headache, pressure in head, nausea or vomiting, dizziness, blurred vision, balance problems, sensitivity to light and confusion and have a worse overall symptom severity score (67 compared with 26). As these sections were able to predict 30-day reattendance, they may be able to predict worse concussive syndromes. Emergency physicians may be able to use the form to

Table 4 The individual breakdown of participant scores on the Emergency Department Concussion Assessment Tool*

Variable	Reattended (n=3)	No reattendance (n=37)	P value
Step 2—orientation	–	–	–
Month (0–1)	1	1.00 (1.00–1.00)	1
Date (0–1)	0	1.00 (1.00–1.00)	0.01
Day (0–1)	1	1.00 (1.00–1.00)	0.776
Year (0–1)	1	1.00 (1.00–1.00)	1
Time (0–1)	0	1.00 (1.00–1.00)	0.021
Step 3—immediate memory	–	–	–
First trial (0–5)	5	4.00 (4.00–5.00)	0.89
Second trial (0–5)	4	5.00 (5.00–5.00)	0.058
Third trial (0–5)	4	5.00 (5.00–5.00)	0.0185
Step 4—symptom screen	–	–	–
Headache (0–6)	5	3.00 (1.75–4.00)	0.0492
Pressure in head (0–6)	5	2.00 (1.00–4.00)	0.0298
Neck pain (0–6)	3	1.00 (0.00–3.00)	0.0611
Nausea or vomiting (0–6)	3	1.00 (0.00–2.00)	0.0145
Dizziness (0–6)	4	1.00 (0.00–3.00)	0.0158
Blurred vision (0–6)	4	0.00 (0.00–0.25)	0.0037
Balance problems (0–6)	4	0.00 (0.00–2.25)	0.0193
Sensitivity to light (0–6)	4	0.00 (0.00–1.25)	0.0017
Sensitivity to noise (0–6)	0	0.00 (0.00–1.25)	0.8773
Feeling slowed down (0–6)	4	2.00 (0.00–4.00)	0.0981
Feeling like in a fog (0–6)	3	0.00 (0.00–3.00)	0.3786
Don't feel right (0–6)	4	3.00 (0.75–4.00)	0.5684
Difficulty concentrating (0–6)	4	2.00 (0.00–4.00)	0.3988
Difficulty remembering (0–6)	2	0.00 (0.00–2.00)	0.3926
Fatigue or low energy (0–6)	3	2.00 (0.00–4.00)	0.1438
Confusion (0–6)	4	0.00 (0.00–2.00)	0.003
Drowsiness (0–6)	5	2.00 (0.00–3.25)	0.2178
More emotional (0–6)	3	1.00 (0.00–3.00)	0.0535
Irritability (0–6)	4	0.00 (0.00–2.00)	0.1241
Sadness (0–6)	0	0.00 (0.00–1.00)	0.9262
Nervous or anxious (0–6)	0	0.00 (0.00–2.25)	0.53
Trouble falling asleep (0–6)	0	0.00 (0.00–2.25)	0.2958
Symptoms were worse with physical activity, number (%)			
Yes	1 (33.3)	4 (10.8)	–
No	0 (0.0)	7 (18.9)	
Unknown	2 (66.7)	26 (70.3)	
Symptoms were worse with mental activity, number (%)			
Yes	2 (66.7)	17 (45.9)	–
No	0 (0.0)	12 (32.4)	
Unknown	1 (33.3)	8 (21.6)	
Step 5—balance examination	–	–	–
Double leg stance (0–10)	0	10.00 (10.00–10.00)	0.074
Single leg stance (0–10)	0	5.00 (0.00–8.00)	0.731

Continued

Table 4 Continued

Variable	Reattended (n=3)	No reattendance (n=37)	P value
Tandem stance (0–10)	0	7.00 (0.00–10.00)	0.319
Tandem gait (0–10)	0	10.00 (0.00–10.00)	0.396

*Values are medians (IQR) unless stated otherwise. No IQR could be generated for reattenders as the sample was too small. In brackets after variables that are scored are the potential scores available for that section.

identify these patients and modify their management plan to reduce the chance of them reattending.

In a previous systematic review on concussion assessment involving 33 studies and 2416 athletes, it was found that a symptoms-based approach is best when trying to identify sports-related concussion.[23] Symptoms most frequently reported were 'headache', 'fatigue', 'difficulty concentrating' and 'dizziness'; two of these symptoms predicted reattendance in our study. They concluded that acute assessment of sports-related concussion should involve neurological, vestibular, ocular motor, visual, neurocognitive, psychological and cervical aspects,[23] which the ED-CAT attempts to do in conjunction with a history and full examination. Hänninen *et al*,[24] in a prospective cohort study of 27 professional ice hockey players, investigated the validity of the SCAT3. They reported that the symptom section of the SCAT3 was the most sensitive in identifying concussed athletes immediately post-injury and the most common symptoms reported were 'don't feel right', 'headache' and 'pressure in head'.[24] An observational case series into the SCAT3 involving 167 patients found that common symptoms reported by athletes included 'headache', 'balance problems' and 'don't feel right'.[25] The symptoms most frequently reported in these three studies show some resemblance to the significant findings in this study, with headache being a common theme. However, some caution must be used as these papers investigated concussion assessment immediately postinjury in athletes. Our study investigated sports and non-sports related concussion with a mean time period between injury and assessment being 45 hours; so, these two populations are not completely comparable. It is worth noting that only five of the 40 cases in this study were sports related.

Our secondary analysis interestingly showed a significant correlation between poor balance and meeting the criteria for a CT head scan. However, it is unlikely that this is going to affect practice as there is already a well-accepted criteria in place for assessing the need for a CT scan post head injury.[10 11]

Strengths and limitations

The primary strength of this quality improvement project is the development of a form that aids concussion

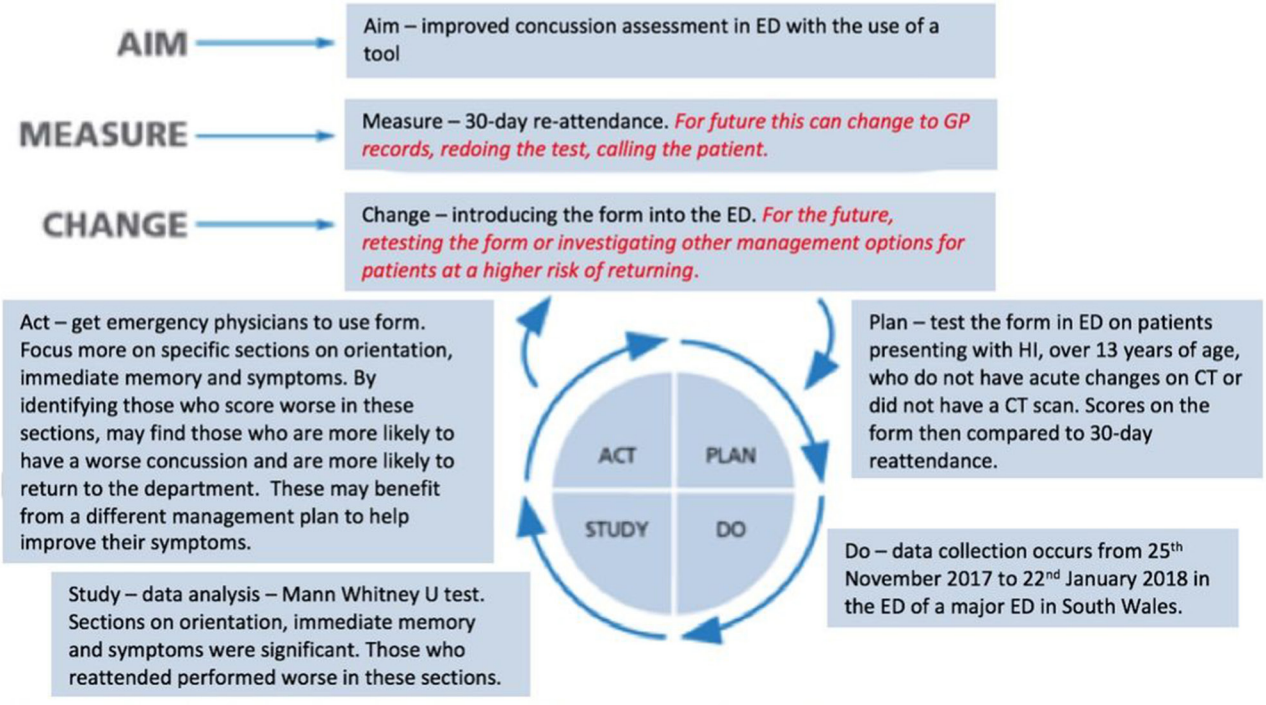

Figure 2 Plan, do, study, act cycle for this quality improvement project.[7]

management, suitable for patients over the age of 13 who present to an ED with a head injury that can predict reattenders. This is the first step to improving the assessment and management of concussion within the ED. Another strength is that one examiner was used and therefore the assessment of each patient was consistent throughout the study.

There are several limitations to this study. Apart from the small sample size, it relies on the assumption that 30-day reattendance to the ED correlates with worse symptoms or a more severe concussion. There were a limited number of positive results, and we were unable to perform multivariate analysis. Unfortunately, other forms of patient follow-up could not be performed due to ethical implications. Future studies should seek to follow-up patients by contacting them 30 days after initial assessment, checking their general practitioner records or reassessing them using the ED-CAT. The time period for follow-up could also be extended beyond 30 days. Convenience sampling was employed during this study, which meant a large section of patients may have been missed out who attended outside the hours when the data collector was not present. Further, this study was performed in a single centre. Future studies should include other hospitals and healthcare systems.

Another limitation of this study, which makes concussion assessment in the ED very difficult, is that we could not compare the postinjury scores of these patients to baseline scores (preinjury).[24 25] One of the findings by Hänninen *et al*[24] was that there was no statistical difference between comparing baseline scores or normative reference scores (devised by the professional league) with the athlete's scores from the day of the injury. Use of reference scores would be useful in the ED, where there is no or little chance of using baseline scores. However, these normative reference scores should take into account age, sex, mechanism of injury and risk factors as a minimum. It may take a while to develop these, but this could be a source of future research to aid ED concussion assessment.

Improvements and studies for the future

Future research should involve expanding this study on a much larger scale. This would ideally be multicentre, not use convenience sampling, have a larger sample size and would need more positive cases. This would therefore enable a more advanced analysis to occur. Power sample size calculations were performed for this study (see online supplementary appendix 5) to show how large a sample size is required if this study was to be repeated. These were performed for each individual section of the ED-CAT and as a result, a range of sample sizes were produced. These ranged from 76 to 1514 for the main sections of the ED-CAT. For future studies, over 400 patients would be required for the study to be powerful enough to validate four of the five sections on the ED-CAT.

It is likely that the current ED-CAT is still too long for implementation in most EDs. Larger studies will confirm those variables that contribute little to concussion assessment in the ED, which can be removed.

Another simple initiative the ED can employ is better discharge advice for those suspected with concussion on top of a head injury leaflet. As we explored earlier, discharge advice for concussion is minimal.[12 13 26] A specific concussion leaflet to be given out in the ED explaining what is it and how to effectively manage the symptoms including return to work or study guidance, similar to the Return to Play guidelines for athletes,[7] may help standardise discharge advice.

CONCLUSION

This quality improvement project has shown that key symptoms, signs and traits highlighted by the ED-CAT were more sensitive to 30-day reattendance in patients over the age of 13 presenting to the ED with a head injury. These sections showed reattenders to have worse orientation, immediate memory and symptoms. These sections therefore may help identify those suffering from a more severe concussion to emergency physicians assessing them in the ED. These patients could then benefit from an altered management plan to aid their recovery from concussion.

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