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by Kylen Swartzberg

Submission date: 28-May-2018 10:21AM (UTC+0200)
Submission ID: 969470009
File name: 221-579e-47de-b4d7-1907b481a69f_K_Swartzberg_MMed_submission.pdf (855.47K)
Word count: 5072
Character count: 27923

A Retrospective review of computer tomography (CT) use by an academic emergency department

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A dissertation submitted to the Faculty of Health Science, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Medicine (Emergency Medicine).

Johannesburg, 2018

Contents

Declaration

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Abstract:

Study Objective

There is growing pressure to reduce unnecessary CT scan imaging requests from the Emergency Department (ED), however acceptable usage rates and diagnostic yields remain scanty. The aim of this study was to describe indications, clinical categories and positive yield rates of patients receiving CT scans in the ED.

Methods

A retrospective record review of all patients who received CT scans at an urban adult academic ED, over a four month period. Primary outcomes were to establish CT scan usage and positive yield rates. Other outcomes included analysis of indications, demographics and anatomical areas scanned.

Results

There were 1 010 scans analysed. The median age of patients was 36 years (4 to 93 years). Males received 64.3% of all scans as well as 75.7% of the scans performed for trauma. The majority of the scans were for trauma patients but non-trauma patients had a higher positive yield however, non-trauma positivity yield rate was 61.8% compared to traumatic positivity yields 47.1% (p-value <0.001). The majority of scans performed were of the head (58%) and neck (20%) with lowest positivity yields rates of 48.9% and 17% respectively. The overall usage rate was 4.6% and overall positivity rate 53.8%.

Conclusions

A negative CT scan does not necessarily mean that the test was not indicated. Higher positivity yield rates may, in fact, reflect insufficient use of CT scanning from the ED. Local guidelines should be established to ensure judicious and effective clinical use of CT scans.

Acknowledgements

I would like to acknowledge Dr Lara Nicole Goldstein for her assistance, conceptualization, advice and guidance throughout the process of this research. As well as her input in editing and encouragement in timeous completion.

I would also like to acknowledge Dr Grace Rubin for her assistance, input and making her department available to conduct the research.

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Introduction

Background:

A computed tomography (CT) scan is an effective imaging tool that can identify many disease processes and alter the management of patients who present to the Emergency Department (ED), especially when the diagnosis is uncertain. [1, 2] It is therefore an invaluable diagnostic tool in emergency medicine and this is evidenced by a substantial increase in the number of CT scans requested by doctors working in the ED. [3]

In an analysis of licensed South African diagnostic imaging equipment, it was found that there are only 5 CT scanners per 1 million general population in South Africa compared to 101 scanners per million population in Japan and almost 41 scanners per million in the United States of America.[4] In a country where 44 million people are dependent on public health resources, the effective and judicious use of CT scanners needs to be scrutinized.[4]

ED doctors are required to correctly manage patients in a timely fashion. They need to rapidly and accurately diagnose and decide on patient disposition while making use of the least invasive modality of diagnostic testing.[5, 6]

The ED is one setting where providers may tend to over-utilize CT scans.[2, 7] Other factors contributing to CT overutilization may include fear of a missed or wrong diagnosis, the potential for malpractice lawsuits, as well as inadequate knowledge and awareness of radiation exposure and potential risk of inducing cancer.[7]

Importance:

There are an abundance of studies evaluating trends in CT scan use in the ED. There is growing pressure to measure and reduce unnecessary imaging in the ED.[8] However, studies describing usage and yield rates remain scanty. Some of these analyses have demonstrated a trend toward decreasing diagnostic yields (defined as the proportion of positive tests among all tests ordered).[8, 9, 10]

To the best of our knowledge there is no guidance for yield rates of emergent CT scan use in southern Africa or acceptable standards set. For these reasons it is important to study the utilization of CT scanning in the ED and to establish acceptable rates of positive yields, in order to monitor the use of this valuable resource.

Goals of this investigation:

Through this retrospective study it was sought to describe the types of CT scans ordered, their indications and clinical categories and establish the positive rate in order to compare to international rates. Other goals were to describe the patients who received CT scans from the ED.

Methods

Study design and setting:

A retrospective record review of all patients who received CT scan investigations, requested from the ED, from 1 January, 2015, to 30 April 2015. The study was performed at an adult, urban, tertiary academic ED in the public sector of one of South Africa's major metropolitan areas.

The ED receives 65,000 annual visits of which approximately 23% are trauma cases. All gynaecological and paediatrics services occur at a sister hospital nearby. The radiology department carries out an average of 700 CT scans per month; these include emergent and non-emergent scans.

Ethical approval was granted by the Human Research Ethics Committee from the University of the Witwatersrand (approval number M160234) as well as the hospital ethics committee.

Selection of Participants:

All scans which were requested and performed on patients from the ED, during the above-mentioned time period were used for the study.

Exclusion criteria included reports not filed or found and illegible information.

Methods and Measurements:

Findings were deemed positive (a scan with a radiological significant lesion related to the indication for the scan) or negative (no radiological lesion) by the primary assessor, an Emergency Medicine resident. Any findings which were ambiguous as to their clinical significance were reviewed by a specialist Emergency Physician as well as a specialist Radiologist, in order to reach consensus of the clinical relevance of the findings. A negative radiological scan may not necessarily be "negative" for the clinician. E.g. an acute ischaemic stroke was deemed a negative radiological scan but does not negate having performed the scan.

Outcomes Measures:

The primary outcomes were to establish the positive finding rate or yield and to compare this to international standard expectations.

Other outcomes included analysis of indications for scans and demographics of patients receiving scans, as these have immediate and long term implications on patient risk versus benefit. As well as analysis of anatomical areas scanned and their findings as these have an auditing relevance as to the use of clinical decision rules.

Analysis:

Patient characteristics and scan results were evaluated using appropriate statistics to create descriptive summaries. Analysis was performed using Microsoft Excel 2010 (Microsoft Corporation) and R Core Team (2015). (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.)

Results

Characteristics of study subjects

There were 1,010 reports collected and analysed. There were 4 reports excluded.

Main results

Scans ordered from the ED constitute 36% of total monthly scans performed in the hospital.

The minimum age of the patients was 4 years and the maximum age was 93 years. The median age was 36 years. Figure 1 shows the breakdown of number of trauma and non-trauma scans performed in each age category. There were 25 reports where ages were omitted due to various reasons. These have not been included in the figure. Figure 2 shows the total number of positive scans in each age category.

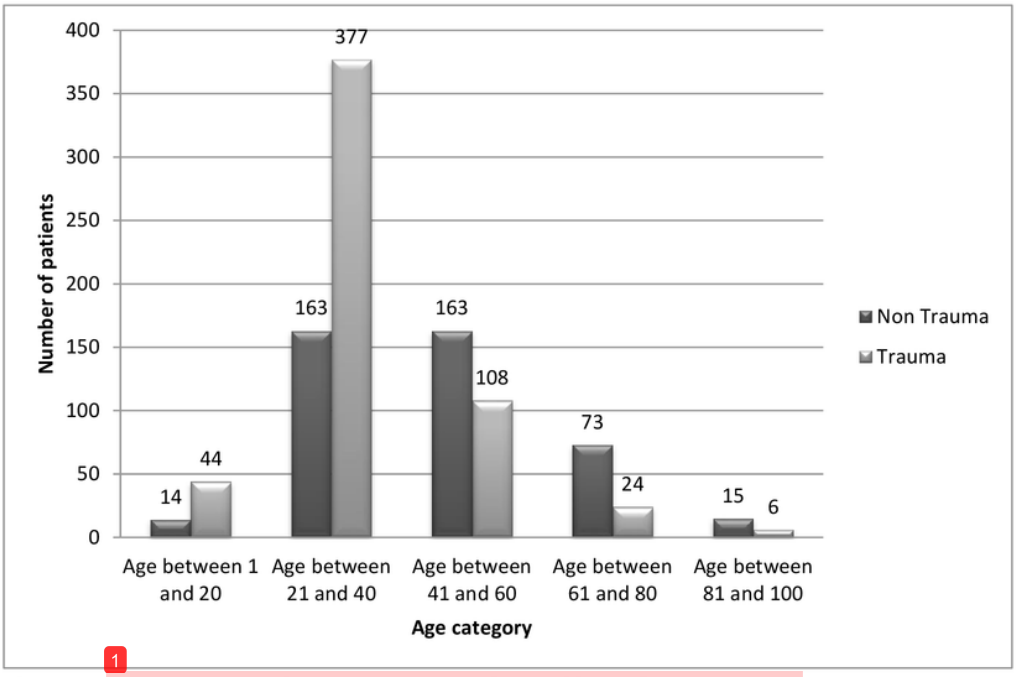

Figure 1: Non-trauma and trauma scans performed in each age category

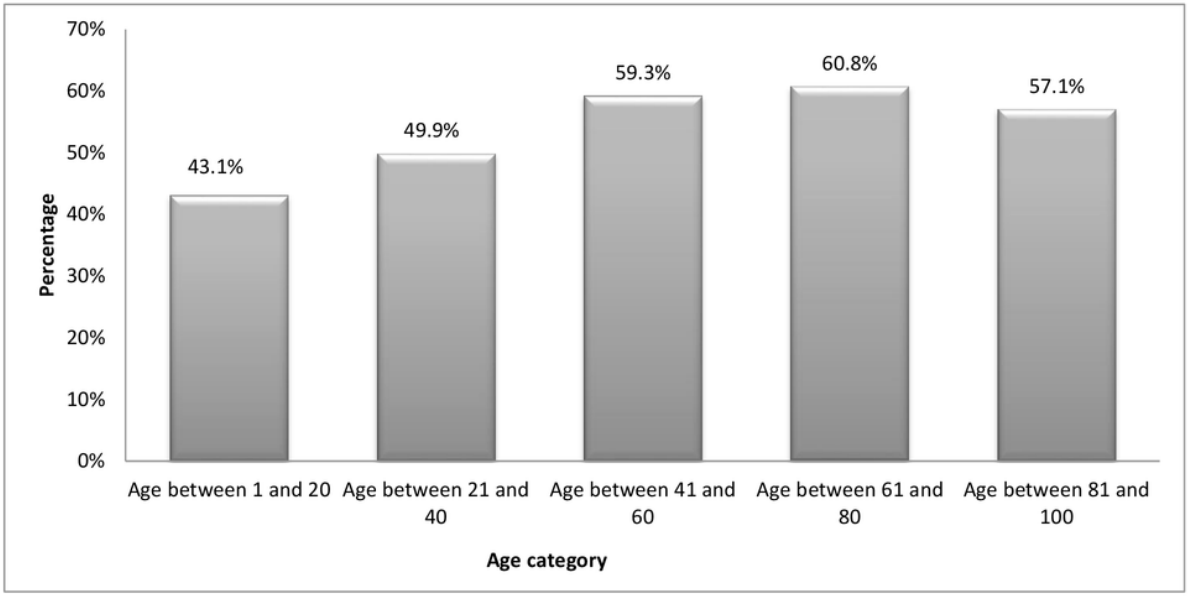

Figure 2: Positive scans according to age categories

Table 1 shows the division of scans for trauma and non-trauma patients. Table 2 shows scans performed for blunt and penetrating trauma. Table 3 shows the total positive yield of scans in each category.

	Male n (%)	**Female** n (%)	**Total** n (%)
Trauma	436 (75.7)	140 (24.3)	576 (57)
Non Trauma	213 (49)	221 (51)	434 (43)
Total	649 (64.3)	361 (35.7)	1010 (100)

Table 1: Trauma and non-trauma according to sex

	Male n (%)	Female n (%)	Total n (%)
Blunt Trauma	339 (72.3)	130 (27.7)	469 (81.3)
Penetrating Trauma	98 (90.7)	10 (9.3)	108 (18.7)

Table 2: Blunt and penetrating trauma according to sex

	Positive Yield n (%)	p-value
Male	355 (54.5)	<0.001
Female	186 (51.5)	
Non-trauma	269 (61.8)	<0.001
Trauma	272 (47.1)	
Penetrating Trauma	58 (54.2)	0.138
Blunt Trauma	214 (45.7)	

Table 3: Positive yield rates in various categories

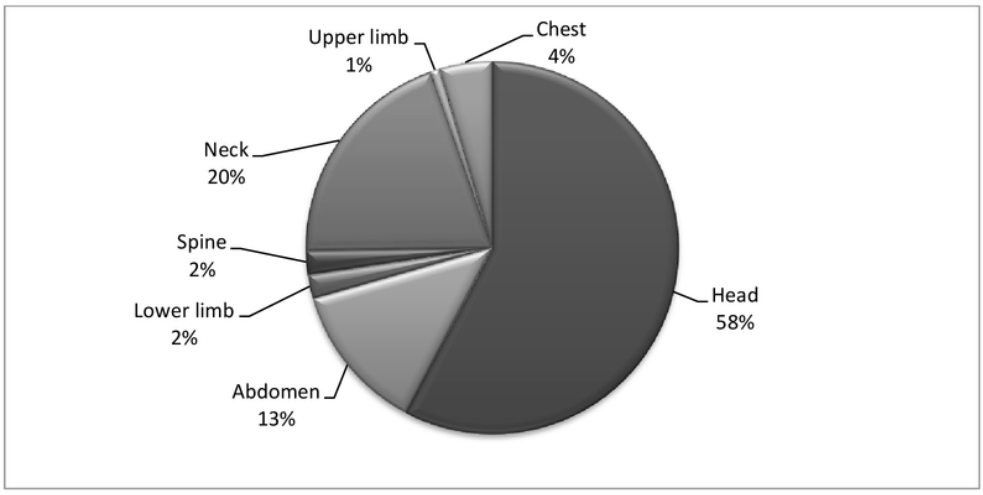

Figure 3: Division of anatomy scanned

Figure 3 represents the percentage of each anatomical region scanned overall. Of the 1,010 individual patients who received CT scans over the period under investigation, 198 patients had two or more anatomical regions scanned, equating to 1,188 total anatomical scans

being performed. Only 7 of 576 patients received full body trauma scans. The CT scan usage rate (number of total ED patients being sent for scan) was 4.6% and overall positive yield was 53.8%.

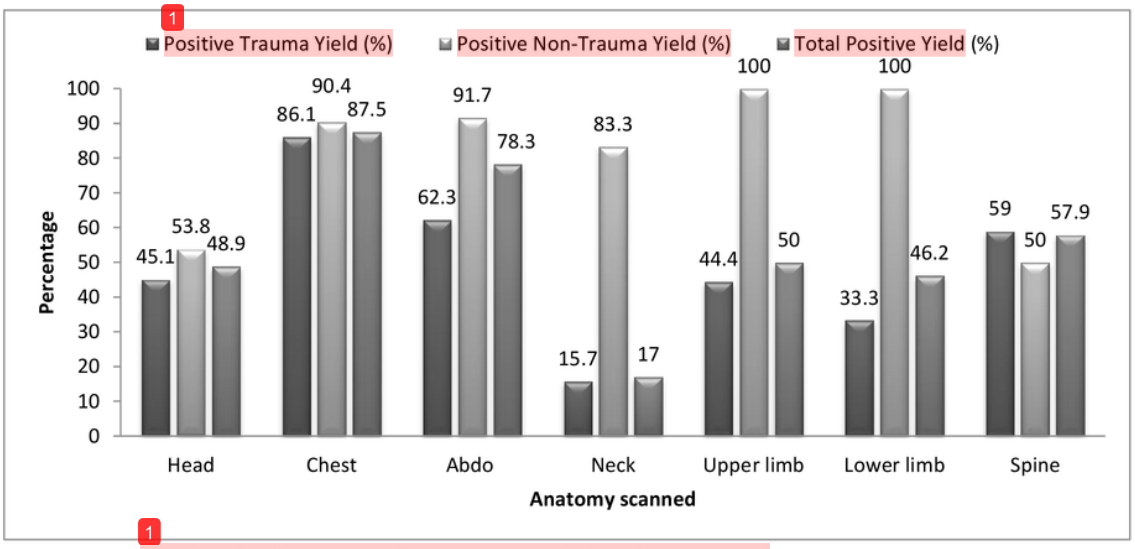

Figure 4: Positive findings according to anatomical region scanned.

Figure 4 represents the positive yield for each anatomical area scanned. Of the 29 blunt trauma abdominal scans which were performed, 19 (65.5%) were positive. There were 361 blunt trauma head CT scans performed, of which 163 (45.15%) had positive findings.

Limitations

Only one assessor was used to make decisions on whether a scan was deemed to have positive or negative findings. Where, in the opinion of the assessor, the results were ambiguous they were then taken to the specialist emergency physician and specialist radiologist for opinion and consensus. Bias may therefore have occurred by the assessor.

Positive radiological scans versus clinically significant scan results were not assessed. A negative radiological scan does not necessarily mean it was not a clinically significant result.

Although the total sample size was reasonable in order to get total positivity rates as the primary outcome, sample sizes for subdivisions of findings were small.

Discussion

The data collected and reviewed in this study is the first of its kind in South Africa, where no guidelines as to acceptable usage rates and positivity yields exist. Usage rates and positivity yields have been found to be on par with international figures.

South African EDs experience one of the highest trauma loads in the world. In 1999 the South African Medical Research Council estimated that 1.5 million trauma cases presented to secondary and tertiary hospitals alone.[11] This results in the investigation of trauma-related scans of particular importance in our setting.

Trauma contributes to 23% of all patient presentations to the ED under review. However trauma patients made up 57% of all scans performed. It is evident that there is a high ratio of scans being ordered for patients presenting with trauma. At the outset it was anticipated that the majority of trauma scans would be for blunt trauma which was confirmed.

As expected there were more male patients scanned due to their significantly higher trauma presentations.[12, 13] This was accompanied by higher positivity rate. Young males have a 27 % higher risk of dying from trauma compared to females due to more severe mechanisms of trauma. Female patients often present to the ED for low-energy trauma.[13] However, when females do present with blunt trauma their main presentations are headache, neck pain and back pain. [13] In a situation where there has been low mechanism of injury but persistent complaints of pain, providers may be obligated to perform imaging for these complaints which may then be a contributing factor to negative scans.

Emergency physicians rely on the results of CT scans to make decisions regarding the further management and disposition of patients. Some of these decisions lead to the need for immediate surgical intervention. Many patients who would have obvious positive findings on CT scan do not go to scan but instead, for various clinical reasons, go directly to the operating theatre. This is a factor which may influence the positivity yield of scans, in that patients being considered for surgical intervention may have a negative scan and then not need to go to theatre. With a cost of around ZAR 126 000 (USD 9 000) for a patient who receives emergent surgery a negative CT scan may be cost-saving as this will avoid the cost and possible negative sequelae of surgery.[14] On the other hand, a positive scan may assist the surgeon and result in a better patient outcome.

The overall positivity rate of the study was 53.8% which is higher than a study by Rigsby et al, which is one of the only studies found to present an overall positive finding rate (40%).[1] However their study only looked at combination of abdominal and pelvic CT scan findings. This study had a rate of 78% for the same combination of CT scans.

Kirschner et al recently published their study with a similar setting to the one in this study where their department was found to have a usage rate of 7.8%.15 (usage rate being defined as the number of patients being sent for scan out of the total number of patients presenting to the ED)

In an ED with over 5000 patient visits per month only 4.6% of patients were sent for CT scan investigation. Factors contributing to the low rate of CT usage are clear clinical decision rules and use of point-of-care ultrasound which impacts decision-making and the diagnostic workup of patients.[16, 17] This is another important indicator of CT scan use, confirmed by the many studies which show that lower rates of use equate to higher positive pick up rates. [8, 9, 10, 18] As the CT usage rate is lower than those of other EDs, there may be an argument that this ED is doing too few CT scans.

Due to lack of published material on total ED CT scan yield rates, this study had to pay attention to anatomical areas in order to find standards for comparison. In so doing it was found that there are wide ranges of positive findings reported and no standards set. As an example; studies looking at positivity rates on non-traumatic head CTs found abnormalities ranging from 10 % to 39% and trauma head CT rates are in the range of 29%. [19, 20, 21] Abnormal findings in this study, for non-traumatic head scans, was 53.8% and traumatic head CT was 45.1% which is also higher than most. A study done in Malaysia reported a positivity rate 70.5%. With such wide ranges it is clear that there is need for a standard to be set or improvement of implementation of protocols.[22]

There was a significant difference in the positivity yield in traumatic and non-traumatic CT scans of the limbs. Both upper and lower non-traumatic scans had a 100% positivity yield compared to trauma scans which had positivity yields of 44% and 33% respectively. There are a few different explanations which may account for this difference:

With traumatic presentations there may be a variety of ways in which injury can present, from fractures, compartment syndrome to obvious open vascular injuries. Many of these may go directly to theatre and therefore not undergo radiological investigation. In a recently published study by Monazzam et al. on CT angiograms of lower extremities with fractures. They found no evidence to support the routine use of CT angiograms to evaluate lower extremity fractures unless at least one hard or soft vascular sign is present.[23] The data of this study does not describe the indication for scans outside of blunt trauma, penetrating trauma and non-trauma therefore the lower yield rates may be due to scans being done without specific indications as mentioned above.

As with the discrepancy between traumatic and non-traumatic limb scans, there was a large discrepancy in positive yield of CT scans performed on the neck.

In non-traumatic neck pathology it is often clinically obvious. Extra- and intra-pharyngeal abscess and masses can be seen, palpated and visualized on ultrasound. These were the majority of non-traumatic indications therefore the expected high yield was confirmed.

In traumatic neck scans there are however confounding issues, despite clinical decision rules being practiced in the ED used in the study. Patients who may initially not need a c-spine scan may later need a scan due to on-going neck pain, there may be distracting injuries in polytrauma patients. In this particular ED, trauma patients who are receiving CT scans of their head often get CT of the neck at the same time. This includes high velocity motor vehicle and pedestrian accidents as well as falls from height. However it was noted that many patients receiving head CTs for isolated blunt injury were receiving neck CTs as well. This may be a factor resulting in the low traumatic CT neck yield rates as explained by Kulvatunyou et al, whereby they found a positivity rate of only 0.7% if a CT scan of the neck was done for isolated direct blunt head injury. They did note that the positive neck findings were more likely to be found in patients who were assaulted and then fell to the ground.[24] Another confounding situation occurs when trauma patients are intoxicated. It is difficult to ascertain whether a decreased level of consciousness is due to intoxication or head injury and these patients may then need a mandatory scan to rule out trauma as a cause, they may receive a neck CT then too.

There are many risks and cost to weigh up when making use of a CT scan, such as actual financial cost, radiation, time and human resources. There can thus be criticism when a scan is negative. The provider can be questioned on the relevant need to have done the scan. A radiological negative scan does not mean the scan was not indicated. This study has looked at the radiological positivity yield of scans done but does not look at the clinical outcome of patients. In non-radiological, clinical practice; making use of special investigations may function as rule out tests. As exemplified by making use of highly sensitive troponins and a clinical decision rule to rule out myocardial infarction.[25] If the troponin result is negative it does not mean the test was unnecessary. Similarly; implementation of radiological related clinical decision rules may result in a significant reduction of CT usage yet translate to an even smaller clinically significant yield.

Lianne et al have made a distinction by calling a scan with intracranial pathology a positive scan and a scan with an acute lesion which accounts for a patient's symptoms a "true positive" scan. [26]

An argument can also be made, where a radiological positive scan does not account for the patient's symptoms: a patient undergoing a CT scan, after meeting criteria according to the Canadian head CT rule for minor head injury, may be found to have a nasal bone fracture yet this is not a clinically significant finding related to the patient's head injury. This is further emphasized by the fact that after implementation of the Canadian head CT rule for minor head injuries, where the CT rate dropped to 32% and the clinically positivity rate was only 8%. [27]

Even though only radiologically significant findings were considered to be a positive yield in this study, it does not mean that a radiologically negative scan was not indicated or clinically significant.

Numerous ways to improve positivity rates have been suggested and validated. Among these are clinical decision rules and protocols. Baghdanian AH et al reported that after implementation of a protocol for blunt abdominopelvic trauma, CT use dropped by 32.1%. The decrease in CT use also increased their positive finding rate. [28]

In the literature there is a large discrepancy between traumatic and non-traumatic patient CT positivity rates.[1] This is confirmed by the findings of this study with positive yield rates of 47.2% and 61.8% respectively. A suggested significant contributor to these findings may be due to the fact that many trauma patients undergo a full body scan when they have a significant mechanism of injury.[1] However in this study of 576 trauma scans, only 7 full body or pan scans were performed. We maintain that there is place for selecting specific anatomical regions for scanning in polytrauma patients based on clinical findings, point-of-care ultrasound findings and implementation of clinical decision rules. It is evident that there is no difference in mortality in patients undergoing immediate full body scans versus those receiving selective anatomical scans. [29]

There are many factors which need to be taken into account regarding the decision to scan a patient. It cannot be a sole decision from a radiologist to state that a scan is not indicated when they are not directly involved with the patient or clinical team. At the same time there is a responsibility on the radiologist to facilitate the judicious use of a very important tool (the CT scan), taking cost, human resource and radiation into account. There is a need for a shared decision to be made with the clinical and radiological team for the best interest of the individual patient and not to regard a negative scan as a wasted effort or use of resource.

This study is the first in South Africa which undertook to look at the overall positivity yield of CT scans done in an academic ED. This is an important indicator as to the effective utilization of CT and an effective auditing tool. It answers the question 'Are we ordering too few or too many CT scans in the emergency department?' A higher utilization rate is associated with a lower positivity rate. [8, 9, 10, 22] With the higher positive yields found in the data reviewed it seems that too few scans are being done. It can, however, be argued that the higher positive yield rates are due to judicious use of CT scans in this resource limited setting.

In a setting where patient numbers to availability of CT scan ratio is amongst the highest in the world there is a need for guidelines or standards to be in place as to the acceptable utilization rates as well as the acceptable positive finding yields in order to monitor the judicious use of this important resource.[4]

It is the hope that these findings will contribute to the development of such local guidelines and standards to ensure judicious and effective clinical use of this modality to improve patient centred outcomes.

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