original article

Patterns of injury detected by pan-computed tomography after road traffic accidents: retrospective review from a trauma center in Saudi Arabia

Ali Al Orf,[a] Khawaja Bilal Waheed,[a] Aftab Ahmed Baig,[b] Khaled Saleh Mohammad,[a] Mohamed Nasr El Sirafy,[a] Muhammad Sohail Amin,[a] Zechriah Jebakumar Arulanatham[c]

From the [a]Department of Radiology, King Fahad Military Medical Complex, Dhahran, Saudi Arabia; [b]Department of General Surgery, King Fahad Military Medical Complex, Dhahran, Saudi Arabia; [c]Research Unit, VDPSR, Prince Sultan Military College of Health Sciences, Dammam, Saudi Arabia

Correspondence: Dr. Khawaja Bilal Waheed · Department of Radiology, King Fahad Military Medical Complex, Dhahran, Saudi Arabia · T: +966138440000 ext: 3222 F:+96613844000-3207 · khawaja@kfmmc.med.sa · ORCID: http://orcid.org/0000-0001-6340-3139

Citation: Al Orf A, Waheed KB, Baig AA, Mohammad KS, El Sirafy MN, Amin MS, et al. Patterns of injury detected by pan-computed tomography after road traffic accidents: retrospective review from a trauma center in Saudi Arabia. Ann Saudi Med 2018; Ann Saudi Med 2018 38(4): 245-250. DOI: 10.5144/0256-4947.2018.245

Received: January 30, 2018

Accepted: April 21, 2018

Published: August 2, 2018

Funding: None.

BACKGROUND: Pan-scan (whole-body) computed tomography (CT) has a paramount role in the diagnosis of injuries in road traffic accidents (RTA).

OBJECTIVE: Identify patterns of injuries on pan-CT scans.

DESIGN: Retrospective medical record review.

SETTING: Tertiary care center.

PATIENTS AND METHODS: The records of all RTA patients who presented to the radiology department at King Fahad Military Medical Complex (KFMMC) in Dhahran for the 3-year period from July 2014 to July 2017 and underwent pan-CT were retrospectively reviewed. Drivers and front-seat passengers with complete clinical information on seating, safety and mechanism of injury were selected. Children under 5 years of age, pregnant women and back-seat passengers were excluded. Patterns of injuries were categorized as 'no abnormality detected' (NAD), isolated or combined head, face and neck (H), isolated or combined chest, abdomen and pelvis (C) or both regions of the body (B).

MAIN OUTCOME MEASURES: Injury patterns on pan-CT scans.

SAMPLE SIZE: 305

RESULTS: Most patients were males (n=287, 94.1%). The median age was 26 years for males (IQR, 22-33 years) and 30 years for females (IQR, 28-39). More than two-thirds were drivers (all males); the remainder were front-seat passengers. Young males were most often involved. The most common type of accident was a roll-over. Of those who sustained injuries, 273 (89.5%) were not wearing a seat belt (unrestrained). The patterns of injuries were NAD (87, 28%), H (27, 9%), C (93, 30.5%), B (98, 32%).

CONCLUSION: When abnormalities were detected, most high-speed vehicular injuries affected the torso. Unrestrained young male drivers are most often involved in RTAs in Saudi Arabia.

LIMITATIONS: Retrospective study with a small sample size. Types and severity of injuries on pan-CT were not documented.

CONFLICT OF INTEREST: None.

The main causes of trauma-related admissions in hospitals worldwide are road traffic accidents (RTA).[1] According to the World Health Organization (WHO), more than a million people are killed on roads, and up to 50 million people are injured worldwide.[2,3] The number of deaths related to vehicular accidents is expected to increase by 2020.[2,3] In Saudi Arabia, the main cause of trauma is road traffic injuries.[3,4] In hospitals under the Ministry of Health, about one-fifth of hospital beds are occupied by RTA victims, who account for 80% of deaths in these hospitals.[5,6] Among all deaths in Saudi Arabia, 4.7% are attributed to road traffic fatalities.[7] Nearly 23% of RTAs in Saudi Arabia involve fatalities in contrast to 2% for fatal collisions in United States.[8] Road traffic fatalities in Saudi Arabia have increased over the last decade from 17 to 24 per 100 000 populations.[2,3]

Factors predisposing to RTAs may include human-related factors (e.g., driver error, driver behavior, driver fatigue, speeding, use of mobile phones during driving, sudden change of road lanes, ignorance about traffic rules and regulations, pedestrian-related mistakes and unlawful road crossings), and non-human or environmental factors (e.g., defective tires and lights, road conditions, traffic flow and congestion, weather conditions).[9,10] However, occupant seating position, safety status (i.e., seat-belt compliance) and mechanism of injury (impact of collision) are key factors determining the extent and severity of vehicular trauma-related injuries.[10,11]

In patients with multiple trauma-related injuries (polytrauma), the use of 'pan-scan' or 'trauma-CT' (i.e., whole-body scan acquiring a plain CT scan of the head and neck followed by an intravenous contrast-enhanced scan of the chest, abdomen, and pelvis) has a paramount role in initial image diagnosis—ascertaining the pattern, severity and extent of injuries needed to direct management.[12] Although there is no clear consensus about indications for pan-scanning, certain clinical injury severity assessment criteria, injury mechanisms and clinical judgement are often used as indications for CT pan-scanning.[13] Also, various studies have shown that clinical assessment may miss underlying injuries that can be picked up by the initial CT pan-scan, improving management and outcome.[14] The sensitivity of initial CT pan-scans reaches 85% for head and neck, thoracic and abdominopelvic injuries.[13] Although there are concerns about increased radiation dose with CT pan-scanning (overselection of regional scanning),[12] its ability to detect clinically unexpected and significant injuries has contributed towards its justification for early and useful imaging.[15,16] Moreover, the radiation dose can be reduced by modern iterative algorithms, particularly for pregnant or pediatric RTA victims.[17,18]

Our 300-bed tertiary care hospital in eastern Saudi Arabia provides immediate care for all emergency trauma patients, including RTA victims. About 1500 patients with RTA presented to the hospital emergency department in the years from 2014 and 2017; of these, the trauma team was activated for about one-third of patients (551 patients). Most of these patients were high-speed vehicular trauma patients because of the hospital's location close to the highway. Trauma team activation at the emergency department leads to an early assessment of clinical condition and severity of injuries, and subsequent CT pan-scanning.

The objective of this study was to identify patterns of RTA injuries detected on CT pan-scans in patients who presented to our hospital emergency department, and summarize information about seating (drivers and front seat passengers), safety (whether restrained or unrestrained) and mechanism of injury (impact of collision). We also compared the regional pattern of injuries in both restrained and unrestrained victims. Studies on RTAs in Saudi Arabia have been published, but none have considered all these parameters for accident patients.

PATIENTS AND METHODS

This medical record review was conducted in the radiology department over a period of 3 years, from July 2014 to July 2017. The records selected for review were those of all RTA patients for whom the trauma team was activated and subsequent CT pan-scans performed. We collected complete clinical information (from the initial trauma management record and patient files) and radiologic (CT scan) findings (retrieved from the Radiology Information System/Picture Archiving and Communication System; RIS/ PACS). The research protocol was approved from the Hospital Research and Ethic Committee. As the study was retrospective and did not involve disclosure of any patient information and privacy, we checked that the files were completely filled out and consent had been provided. All clinical and radiologic information was kept strictly confidential. A literature review was performed through electronic search (Google Scholar, PubMed).

Only single-vehicle accident patients (car driven by patient hit by another car) with 'complete clinical information' on seating, safety and mechanism of injuries) were included. Seating information whether driver or front-seat passenger and 'safety' information (whether restrained or unrestrained) were acquired. Back-seat passengers (assuming their variable level of alertness and injury susceptibility, not facing directly the steering wheel assembly, instrument panel and

wind-screen or header surfaces unlike drivers and front seat passengers) and babies less than 5 years (usually requiring properly installed car seats) were excluded. Pedestrians, heavy-vehicle (trucks and buses due to their larger built and heights) accident victims were also excluded. 'Mechanism of injury' was categorized as roll-over (including those with ejection of occupant), frontal collision, side-impact and rear impact.

Trauma team activation announced by the emergency department consultant after trauma triage was based on the Canadian Triage and Acuity Scale, which was followed by primary assessment by the trauma team leader (senior specialist general surgery) who determined the need for pan-scanning. Based on hospital policies, indications for such pan-CTs were based on clinical information (including high-risk mechanism of injury involving roll-over mechanism with ejection of passenger from the vehicle or death of an accompanying person), clinical condition (e.g., compromising vital parameters, unconscious patient with suspected polytrauma), injury severity assessment (considering at least 3 moderate, 2 severe or 1 serious regional injury) and clinical judgement (expectation severe or multiple injuries). For patients referred for pan-CT based on injury severity assessment, an injury severity score had to be 12 or more for inclusion in our study (considering abbreviated injury scale/AIS values of 1, 2, 3 and 4 for minor, moderate, severe and serious injuries). CT scans were performed in our radiology department on a 128-slice CT scanner machine (SOMATOM Definition Flash Siemens, Munich Germany) and included plain studies of the the head, face and neck followed by intravenous contrast-enhanced studies of the chest, abdomen and pelvis. The studies were modified by either regional angiograms in cases of suspected vascular injuries or by delayed imaging of the abdomen and pelvis in cases of urinary tract injuries or suspected contrast extravasations, as decided by the on-call supervising radiology specialist that day. Patients who came later (within 3 months of discharge) with imaging findings relevant to their initial RTAs, were also considered.

Patterns of injuries were categorized as no trauma-related abnormality detected, isolated or combined head, face and neck (H), isolated or combined chest, abdomen and pelvis (C) or both regions of the body (B). Patterns of injuries on pan-CT scans were reviewed by two general radiologists (having more than 10 years of experience in body imaging) initially blinded of clinical information. Insignificant findings like muscle spasm, isolated minimal (1-2 mm) subgaleal hematoma without underlying fracture or neurologic deficit, isolated minimal pleural reaction and non-trauma related or incidental findings like thyroid nodule, splenunculi, ovarian cyst, or rib anomaly were also considered as NAD. Although no major discrepancies were found in initial scan interpretations, when ambiguity arose, a third senior radiologist who was also experienced in the same imaging was consulted and a final decision was made by consensus of three radiologists.

The median and interquartile range are used to summarize the age of patients since the data was not normally distributed. Categorical variables are described as frequency and percentages. The proportions of injuries for restrained and unrestrained drivers and passengers were compared by the chi-square test. The statistical analysis was carried out using IBM SPSS version 22 (IBM Corp, Armonk, NY). A *P* value of .05 was considered statistically significant.

RESULTS

Of 572 RTA patients who presented at our hospital emergency department in 3 years (between July 2014-July 2017), 305 patients (drivers and front-seat passengers) with complete clinical information and radiologic imaging were selected for analysis (**Table 1**). The median (IQR) age of males was 26 years (IQR, 22-33 years), and that of females was 30 years (IQR, 28-39). More than two-thirds were drivers (all males) and the remainder were front-seat passengers.

No trauma-related abnormality was detected (NAD) on pan-CT scans in 87 patients (30.5%), while isolated or combined head, face and neck (H) injuries occurred in 27 (8.8%), and isolated or combined chest, abdomen and pelvis (C) injuries occurred in 93 (30.5%); both regions of the body were injured in 98 (32.1%) cases (**Figure 1**). Most of the accident victims were unrestrained (n=273, 89.5%). Mechanisms of injury were 'roll-over' in 213 cases (69.8%), followed by 'frontal collisions' in 70 (23%), 'side-impacts' in 16 (5.2%) and 'rear-impacts' in 6 cases (1.9%). No abnormality was detected 10% more often in restrained than unrestrained patients and 4% more head, face and neck injuries occurred in restrained than in unrestrained patients.

Table 1. Road traffic accident victims by seating and safety status (n=305).

Safety	Drivers		Front seat passengers	
	Male	Female	Male	Female
Restrained	27 (11.7)	0	4 (7.0)	1 (5.6)
Unrestrained	203 (88.3)	0	53 (93.0)	17 (94.4)
Total	230	0	57	18

Values are n (%).

In unrestrained patients there were 3% more isolated or combined chest, abdomen and pelvis injuries and 10% more injuries of both regions than in restrained patients. Death occurred only among the unrestrained victims (12 patients, 3.9%) and all had injuries in both regions. Differences in injury patterns in restrained and unrestrained victims were not statistically significant (*P*=.43).

DISCUSSION

When abnormalities were detected, we found that the most common vehicular injuries affected the torso/trunk region in both restrained and unrestrained patients, a finding that differs from earlier studies conducted in the region that found that most involved the head and neck and appendicular skeleton. Barrimah reported more head and neck injuries in the Al-Qassim region.[19] Data from Riyadh in 2013 reported a lower number of such injuries.[8] This varied pattern of injuries was also highlighted in a systematic review by Mansuri in 2014 who observed under-reporting and disorganized data (data inconsistency) to be major limitations in acquiring quality RTA data.[6] Patients were also excluded from out study because of incomplete information. Other studies reported more appendicular injuries in RTAs.[19,20] Appendicular injuries were not considered in our study as these are not usually covered by the pan-CT, limiting the true extent of injuries. However, we recommend that radiologists look carefully for torso injuries in both restrained and unrestrained RTA victims as this region was most commonly affected in the high-speed vehicular accidents on highways in our study. Cheynel also found that abdominopelvic injuries were the most commonly seen injuries in severely injured hospitalized RTA patients.[21]

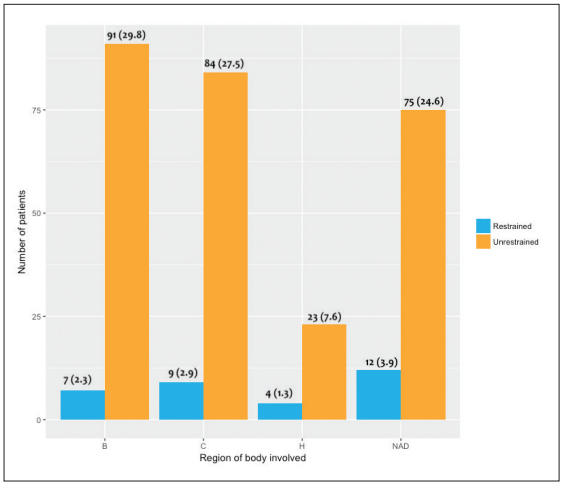

Figure 1. Pattern of injuries on pan-CT scans in road traffic accident patients (NAD: no abnormality detected, H: isolated or combined head, face and neck, C: isolated or combined chest, abdomen and pelvis, and B: both regions. Number and percentage at top of bar) (*P*=.43).

Cervical and whiplash injuries were more common in restrained patients in our study, which is similar to other studies.[22,23] Also, 'normal scans' were more frequent in the restrained group (37.5%) than in the unrestrained group (27.4%). Although the results were not statistically significant, we believe the differences to be clinically important, highlighting the importance of seat belt compliance. Based on our study and several other studies that evaluated seat-belt compliance with less severe injuries,[23,24] we strongly suggest that safety education be part of an accident prevention policy to reduce overall injuries.

The finding that young males are the most common victims is concerning as they represent a productive proportion of the population in terms of social and economic growth. Nearly every prior study in Saudi Arabia has highlighted this concern.[6,9] Females will be able to drive legally in June of 2018, which will increase the size of the productive population impacted by RTAs. Government policies, strict traffic rules and fair issuance of driving licenses, better road infrastructure and effective traffic monitoring tools are therefore needed to reduce such accidents, and some of these measures are already enforced.[19] Frequent campaigns and education programs, particularly among the youth, are proposed to promote awareness of safe driving and RTA consequences.

Serious injuries occurred in both restrained and unrestrained patients in our study, highlighting the fact that these high-speed vehicular accidents are dangerous, causing high-impact force or mechanical trauma to the body (compression or crushing forces, acceleration-deceleration mechanisms). Roll-over, the most common mechanism of injury, was accompanied by ejection of passengers in many cases, further aggravating the extent and severity of injuries by adding external stimuli. In a review by DeNicola, over-speeding was noted as the commonest cause of road traffic collisions.[25] Therefore, safe driving, following speed limits and observing traffic rules are very important. Avoidance of sudden lane changes and distractions (like mobile phone usage), road rage, racing and tailgating, all help to reduce the risks of accidents and need to be highlighted in public campaigns.

Because of incomplete or inadequate clinical information, many patients were excluded, limiting the size of the sample to study. Children under 5 years were excluded as they require adequately installed car seats

and information on the utility and proper installation of car seats was lacking. Also, patterns and the severity of injuries in children might differ from adults due to greater body flexibility and soft bones. Back-seat passengers were not included as they do not share the same level of alertness and threat as front-seat passengers and drivers; they also encountera variable level of alertness, safety zone (behind the front-seat cushion, not facing directly the steering wheel assembly, instrument panel and wind-screen or header surfaces) and airbag position. Truck drivers were excluded because of different forces and injury dynamics related to the size and height of the vehicles.

In our study, clinical judgment of suspected polytrauma, the clinical condition of the patient (deteriorating vital signs) and clinical observations (high-risk mechanism of injury) were considered for pan-CT requests in addition to an injury severity score of 12 or more. This might have contributed to the high rates of negative pan-scans (around 30%) in our study, and warrants strict implementation of a trauma scoring system to limit unnecessary scans and to reduce associated high radiation doses. Injury types and severity on pan-scans were not categorized by CT grading, which is not available (except for solid abdominal viscera) for each organ or region of the body (e.g., hollow-viscus, mediastinum or retroperitoneum), and may not correlate well with the clinical severity score or condition of the patient. Although assessment of the severity of injuries was not a main subject of our study, inclusion of clinically or radiologically insignificant injuries (if not defined) might lead to overestimation of regional injuries. Future studies might evaluate patterns of vehicular injuries considering certain other information (like vehicle characteristics, vehicle speed and lane, functional airbag system, and delays in transport to trauma care center) and correlate severity scores after imaging with types and grades of injuries.

In conclusion, high-speed vehicular injuries commonly involve roll-overs and mostly affect the torso. Unrestrained young male drivers are primarily affected. Recognizing patterns of injuries on pan-CT scans may allow for prompt identification of additional affected areas in these trauma patients.

REFERENCES

1. World Health Organization. Global Health Observatory (GHO) data. World Health Statistics 2010. [cited on 2014 March] Geneva (CH): World Health Organization; 2010.
2. World Health Organization. Global Status Report on Road Safety 2013. Geneva (CH): World Health Organization; 2013.
3. WHO. World Health Organization. Saudi Arabia (Factsheet). (2014). Available from: http://www.who.int/violence_injury_prevention/road_safety_status/2013/country_profiles/saudi_arabia.pdf
4. Ansari S, Akhdar F, Mandoorah M, Moutaery K. Causes and effects of road traffic accidents in Saudi Arabia. Public Health. 2000;114(1):37-39. https://doi.org/10.1016/S0033-3506(00)00306-1. PMID:10787024.
5. Aldawood AS, Alsultan M, Haddad S, Alqahtani SM, Tamim H, Arabi YM. Trauma profile at a tertiary intensive care unit in Saudi Arabia. Ann Saudi Med. 2012;32(5):498-501. https://doi.org/10.5144/0256-4947.2012.498. PMID:22871619.
6. Mansuri FA, Al-Zalabani AH, Zalat MM, Qabshawi RI. Road safety and road traffic accidents in Saudi Arabia. A systematic review of existing evidence. Saudi Med J. 2015;36(4):418-424. https://doi.org/10.15537/smj.2015.4.10003. PMID:25828277.
7. Al-Naami MY, Arafah MA, Al-Ibrahim FS. Trauma care systems in Saudi Arabia: an agenda for action. Ann Saudi Med. 2010;30(1):50-58. https://doi.org/10.5144/0256-4947.59374. PMID:20103958.
8. Hassan HM, Al-Faleh H. Exploring the risk factors associated with the size and severity of roadway crashes in Riyadh. J Safety Res. 2013;47:67-74. https://doi.org/10.1016/j.jsr.2013.09.002. PMID:24237872.
9. Al Turki YA. How can Saudi Arabia use the Decade of Action for Road Safety to catalyse road traffic injury prevention policy and interventions? Int J Inj Contr Saf Promot. 2014;21(4):397-402. https://doi.org/10.1080/17457300.2013.833943. PMID:24047249.
10. Mogaka EO, Ng'ang'a Z, Oundo J, Omolo J, Luman E. Factors associated with severity of road traffic injuries, Thika, Kenya. Pan Afr Med J. 2011;8:20. PMID:22121429.
11. Ratanavarah V, Suangka S. Impacts of accident severity factors and loss values of crashes on expressways in Thailand. IATSS Res. 2014;37(2):130-136. https://doi.org/10.1016/j.iatssr.2013.07.001.
12. Jiang L, Ma Y, Jiang S, Ye L, Zheng Z, Xu Y, Zhang M. Comparison of whole-body computed tomography vs selective radiological imaging on outcomes in major trauma patients: a meta-analysis. Scand J Trauma Resusc Emerg Med. 2014; 22:54. doi: 10.1186/s13049-014-0054-2. PMID: 25178942.
13. Treskes K, Saltzherr TP, Luitse JS, Beenen LF, Goslings JC. Indications for total-body computed tomography in blunt trauma patients: a systematic review. Eur J Trauma Emerg Surg. 2017;43(1):35-42. https://doi.org/10.1007/s00068-016-0711-4. PMID:27435196.
14. Stengel D, Ottersbach C, Matthes G, et al. Accuracy of single-pass whole-body computed tomography for detection of injuries in patients with major blunt trauma. CMAJ. 2012;184(8):869-876. https://doi.org/10.1503/cmaj.111420. PMID:22392949.
15. Caputo ND, Stahmer C, Lim G, Shah K. Whole-body computed tomographic scanning leads to better survival as opposed to selective scanning in trauma patients: a systematic review and meta-analysis. J Trauma Acute Care Surg. 2014;77(4):534-539. https://doi.org/10.1097/TA.0000000000000414. PMID:25250591.
16. Asha S, Curtis KA, Grant N, et al. Comparison of radiation exposure of trauma patients from diagnostic radiology procedures before and after the introduction of a panscan protocol. Emerg Med Australas. 2012;24(1):43-51. https://doi.org/10.1111/j.1742-6723.2011.01504.x. PMID:22313559.
17. Van Vugt R, Keus F, Kool D, Deunk J, Edwards M. Selective computed tomography (CT) versus routine thoracoabdominal CT for high-energy blunt-trauma patients. Cochrane Database Syst Rev. 2013;(12):CD009743. PMID:24363034.
18. Stengel D, Ottersbach C, Kahl T, et al. Dose reduction in whole-body computed tomography of multiple injuries (DoReMI): protocol for a prospective cohort study. Scand J Trauma Resusc Emerg Med. 2014;22(1):15. https://doi.org/10.1186/1757-7241-22-15. PMID:24589310.
19. Barrimah I, Midhet F, Sharaf F. Epidemiology of road traffic injuries in qassim region, saudi arabia: consistency of police and health data. Int J Health Sci (Qassim). 2012;6(1):31-41. https://doi.org/10.12816/0005971. PMID:23267302.
20. Cheynel N, Gentil J, Freitz M, Rat P, Ortega Deballon P, Bonithon Kopp C. Abdominal and pelvic injuries caused by road traffic accidents: characteristics and outcomes in a French cohort of 2,009 casualties. World J Surg. 2011;35(7):1621-1625. https://doi.org/10.1007/s00268-011-1136-1. PMID:21562868.
21. Singh R, Singh HK, Gupta SC, Kumar Y. Pattern, severity and circumstances of injuries sustained in road traffic accidents: a tertiary care hospital-based study. Indian J Community Med. 2014;39(1):30-34. https://doi.org/10.4103/0970-0218.126353. PMID:24696537.
22. Bannister G, Amirfeyz R, Kelley S, Gargan M. Whiplash injury. J Bone Joint Surg Br. 2009;91(7):845-850. https://doi.org/10.1302/0301-620X.91B7.22639. PMID:19567844.
23. Abbas AK, Hefny AF, Abu-Zidan FM. Seatbelts and road traffic collision injuries. World J Emerg Surg. 2011;6(1):18. https://doi.org/10.1186/1749-7922-6-18. PMID:21619677.
24. Bendak S. Seat belt utilization in Saudi Arabia and its impact on road accident injuries. Accid Anal Prev. 2005;37(2):367-371. https://doi.org/10.1016/j.aap.2004.10.007. PMID:15667824.
25. DeNicola E, Aburizaize OS, Siddique A, Khwaja H, Carpenter DO. Road Traffic Injury as a Major Public Health Issue in the Kingdom of Saudi Arabia: A Review. Front Public Health. 2016;4:215. https://doi.org/10.3389/fpubh.2016.00215. PMID:27747208.