



A 5-year review of a pitch side radiology unit at an international sports stadium

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Abstract

Background The increased strength and conditioning of elite athletes has led to greater potential for high impact injuries. With increasing concerns for player welfare, the decision to return to play after sustaining an on-field injury is complex.

Aim Review of a 5-year experience of a pitch side radiology unit (PSRU) at a large international sports stadium.

Methods X-rays were acquired in a purpose built pitch side radiology unit (PSRU) within a large international sports stadium (Aviva Stadium) using a mobile digital X-ray unit. All x-rays were performed at the Aviva stadium's PSRU from October 2012 to March 2018.

Results From October 2012 to March 2018, 89 competitive sport matches were held at the international sports stadium. 43/89 (48%) matches required the PSRU, with rugby matches having the highest utilization rates (34/47, 72.3%). In 89 matches, a total of 79 x-rays were performed (0.89 x-rays/match). The highest percentage of sports players undergoing imaging was rugby players (70/79, 88.6%). Overall, the majority of x-rays were of the upper limbs (49/79, 62.0%) and lower limbs (25/79, 31.6%). 17/79 (21.5%) x-rays demonstrated an acute bony injury, 15/17 (88%) of which were rugby players.

Conclusion The PSRU at the Aviva international sports stadium is well utilized and allows for a rapid diagnosis of osseous injuries sustained on the field of play. It provides a useful adjunct to the pitch side clinical assessment by medical staff. It provides a privacy and strategic advantage to players compared with hospital-based services. Consideration should be given to installing similar PSRUs at major sports stadiums around the world.

Keywords Athletic injury · Radiology · Sports · X-ray

Introduction

The increasing physicality of professional contact sports has led to higher injury rates and increasing concerns regarding athlete welfare, as demonstrated in studies from recent Winter [1] and Summer Olympic Games [2–4] and Commonwealth Games [5]. Athletes sustaining on-field injuries now require rapid and comprehensive assessment to facilitate the medical

team to make informed “return to play” decisions or to instigate early rehabilitation programs. In the past, this has been limited to a clinical assessment; however, the emergence of pitch side radiology units (PSRUs) offers the possibility of instant radiological assessment to augment the clinical findings of the on-field medical staff. In this study, we evaluate the role of the PSRU over a period between 2012 and 2018.

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Methods

The Aviva international sports stadium is a 51,700 seater international sports stadium in Dublin, Ireland. The PSRU is a custom-built radiology unit housed in the stadium's medical treatment room equipped with a mobile radiography unit (GE AMX 4, GE Healthcare). The PSRU opens on match day at the commencement of play and closes 1 h after the cessation of competition time. It is staffed by an accredited radiographer

and musculoskeletal radiologist on competition day, and physiotherapist when required to resolve technical issues particularly at the service start-up. X-ray requests are accepted from the team doctors on a standardized requisition form outlining the player's details, clinical information, and x-ray region required. Access to the unit is limited to players only. X-rays are reviewed by the on-site radiologist using a dedicated high-resolution workstation, which is isolated from networks with 3-megapixel resolution (Barco) monitor located within the PSRU. A verbal report is issued at the time of image acquisition. At the end of each match, the acquired images are exported onto CD and transferred securely to Mater Private Hospital and incorporated into the Mater Private RIS/PACS system. A formal radiology report is issued to the referring doctor. If required, transfer of images onto CD can be performed for visiting teams on site before the player leaves the stadium.

Data on radiological investigations performed at the international sports stadium was retrospectively collected from the Carestream PACS, the radiology software used for storing all imaging data. Data was collected, stored, and analyzed in strict compliance with data protection and athlete confidentiality. Data are presented as frequencies and proportions. All numbers have been rounded to one decimal place.

Results

Over a 5-year period from October 2012 to March 2018, 89 professional sporting fixtures were held in the Aviva international sports stadium. As outlined in Table 1, this comprised of 47 rugby (52.8%), 40 soccer (44.9%), and 2 American football matches (2.2%). A total of 43/89 matches (48.3%) utilized the PSRU at the Aviva stadium. A total of 79 x-rays were acquired over these 89 matches (0.89 x-rays/match). The average turnaround between x-ray request and image acquisition was 9.6 min.

The PSRU was utilized in 34/47 (72.3%) of rugby matches, 7/40 (17.5%) soccer fixtures, and 2/2 (100%) American football matches. The 47 rugby matches accounted for 70 x-rays

Table 2 Acute injuries identified on x-ray by sport type

Sport	Number of x-rays	Number of acute injuries on X-ray	Positivity rate
Rugby	70	15	15/70 (21.4%)
Soccer	7	1	1/7 (14%)
American Football	2	1	1/2 (50%)
Total	79	17	17/79 (21.5%)

(70/79, 88.6%), 40 soccer fixtures accounted for 7 x-rays (7/79, 8.9%), and 2 x-rays were taken in both American football fixtures (2/79, 2.5%). The number of x-rays per match ranged from 1 to 5 (Fig. 4).

The upper limb was the most frequently imaged anatomical location comprising 49/79 (62.0%) x-rays (Fig. 5). The lower limb was the second most frequently imaged region with 25/79 (31.6%) x-rays. In rugby, the majority of the x-rays were of the upper limb (46/70, 65.7%), compared with soccer with majority of x-rays taken of the lower limbs (5/7, 71.4%) of soccer players.

Seventeen acute findings were identified on the 79 x-rays (17/79, 21.5%), comprising 16 acute fractures and 1 joint dislocations. The majority of the acute injuries were sustained in rugby players (15/17, 88.2%), with one acute injury in a soccer player (1/17, 5.9%) and one in an American football player (1/17, 5.9%). 13/17 (76.5%) of these injuries were located in the upper limb, almost exclusively seen in rugby players (12/13, 92.3%). 3/17 (17.6%) of the acute injuries were located in the lower limb, 2/3 (66.7%) and 1/3 (33.3%) were identified in rugby and soccer players respectively.

The most frequent diagnosis was a fracture of the distal radius (5/17, 29.4%), phalanx (4/17, 23.5%), metacarpal (2/17, 11.8%), proximal humerus (2/17, 11.8%), tibia (1/17, 5.9%), fibula (1/17, 5.9%), and metatarsal (1/17, 5.9%). There was one rib dislocation (1/17, 5.9%). The overall positivity rate (Table 2) of acute findings on x-rays was 17/79 (21.5%). Per sport, the positivity rate was 15/70 (21.4%), 1/7 (14%), and 1/2 (50%) for rugby, soccer, and American football respectively.

Table 1 Volume and utilization of the PSRU by sport type

Sport	Total number of sporting fixtures	Utilization of the PSRU	Number of total x-rays acquired	Number of players X-rayed/match
Rugby	47 (52.8%)	34/47 (72.3%)	70 (88.6%)	1.49
Soccer	40 (44.9%)	7/40 (17.5%)	7 (8.9%)	0.18
American Football	2 (2.2%)	2/2 (100%)	2 (2.5%)	1.0
Total	89	43/89 (48.3%)	79	0.89

Discussion

This review was undertaken to assess the relative clinical value of an on-site purpose built PSRU at a major sporting stadium in the immediate assessment of sporting injuries in elite sports men and women. Recognizing the unique design issues, lead lining to ensure safe use, requirement for an on-site radiologist and radiographer on match day and intermittent quality assurance checks by physicists, deployment cannot be undertaken without detailed consideration. This review was undertaken to determine whether all the difficulties and complexities inherent in such deployment can be justified based on utilization and impact on player management. Quantifying value is difficult and balances recognition that for some players, early diagnosis and commencement of therapy may be critical in allowing the earliest possible time to return to sporting participation. In this study, immediate x-ray during or immediately after a game allowed some rugby players to return to participation in a major fixture within 6 days of injury. Although utilization may appear relatively low, recognizing the economic aspects of elite player injury and early assessment as observed in this study, the costs incurred in deploying a PSRU can be justified.

Imaging now plays an increasingly important role at professional sporting events. Recent Winter [1] and Summer [2–4] Olympics have highlighted the success of dedicated radiological services housed within medical polyclinics within the games village. To the best of our knowledge, this is the first study evaluating the utilization of a purpose built PSRU co-located within an international sports stadium. Over the 5-year period from 2012 to 2018, the PSRU was well utilized, required in almost half (43/89, 48.3%) of professional sporting fixtures at the Aviva stadium. In total, 79 x-rays were acquired, with rugby players demonstrating the highest utilization rates comprising 70/79 (88.6%), an average of 1.49 rugby players x-rayed per match.

X-rays of the upper extremities were more frequently imaged than other body part and were almost twice as frequently



Fig. 1 Co-location of the PSRU (black arrow) within the medical treatment room in Aviva stadium



Fig. 2 The digital x-ray and ultrasound machines housed within the PSRU

imaged compared with the lower limbs (49 x-rays vs 25 x-rays). This differed significantly from prior studies evaluating injury surveillance of elite athletes at sporting events, including the 2016 Summer Olympics [4], FIFA World Cup [6], and 2015 Rugby World Cup [7]. This finding is likely attributed to the fact that the PSRU was aimed at solely detecting an acute osseous abnormality, rather than assessing for soft tissues injuries that would require other imaging modalities (for example MRI and CT) available at the abovementioned professional sporting events. The advantage of having a radiologist on-site within the stadium allowed for the judicious and appropriate use of x-rays within the PSRU. While no x-ray referral request was formally denied, recommendations for an MRI or CT as an alternative or follow-up imaging modality were discussed with the referring team doctor.

The custom built PSRU is housed inside the medical treatment room at the Aviva stadium (Fig. 1). The design and construction of the PSRU had to conform to the relevant radiation protection legislation, as well as accounting for unique challenges. This included designing a room that would only

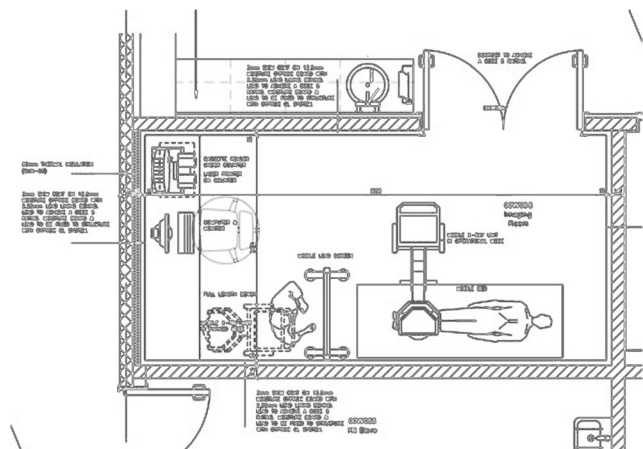


Fig. 3 Layout of the PSRU in Aviva stadium

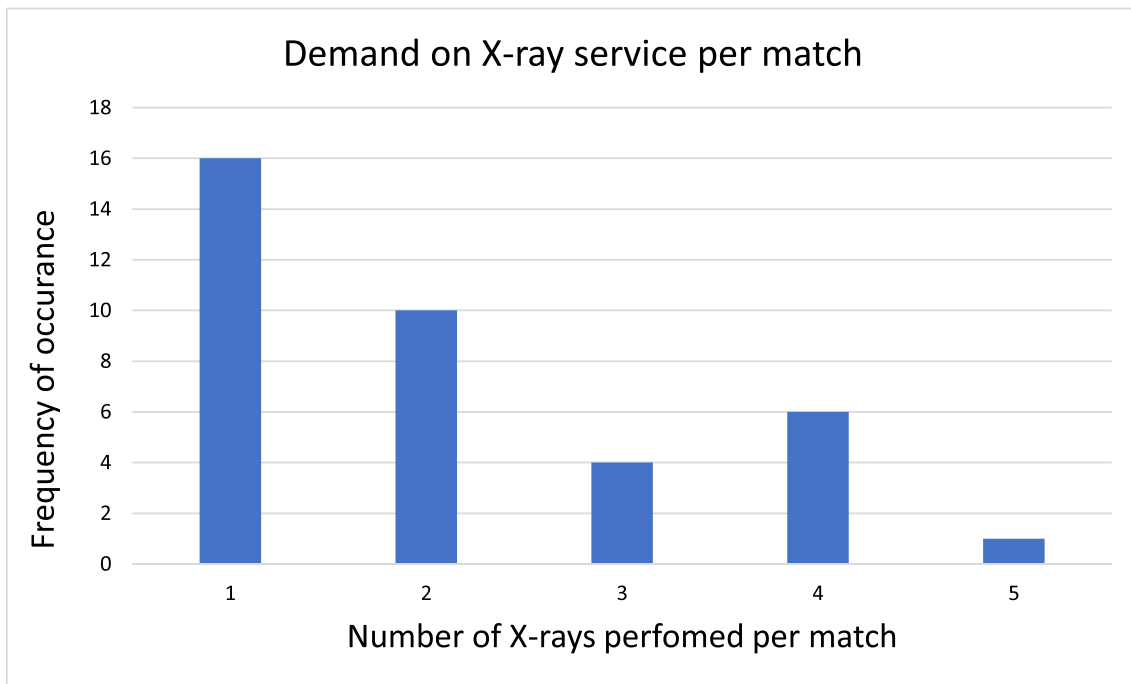


Fig. 4 Demand on x-ray service per match

require intermittent use (1–2 times per month), survive in a robust environment, provide instant image access and on the spot diagnosis, and meet the expected financial and safety requirements. The ultimate configuration of the PSRU consisted of a mobile radiographic unit (GE AMX 4), lead shield, and single plate Carestream phosphor plate reader housed within a 15 m² facility (Figs. 2 and 3). An initial

design was based on a direct digital x-ray room; however, this was not felt to be appropriate as the environment conditions, in particular humidity and room temperature, were not guaranteed. For this reason, a phosphor plate system was chosen. The robust technology deployed in the PSRU is of relatively low cost, small footprint, safe and easy to use, and suitable for intermittent use in a non-radiology department setting with

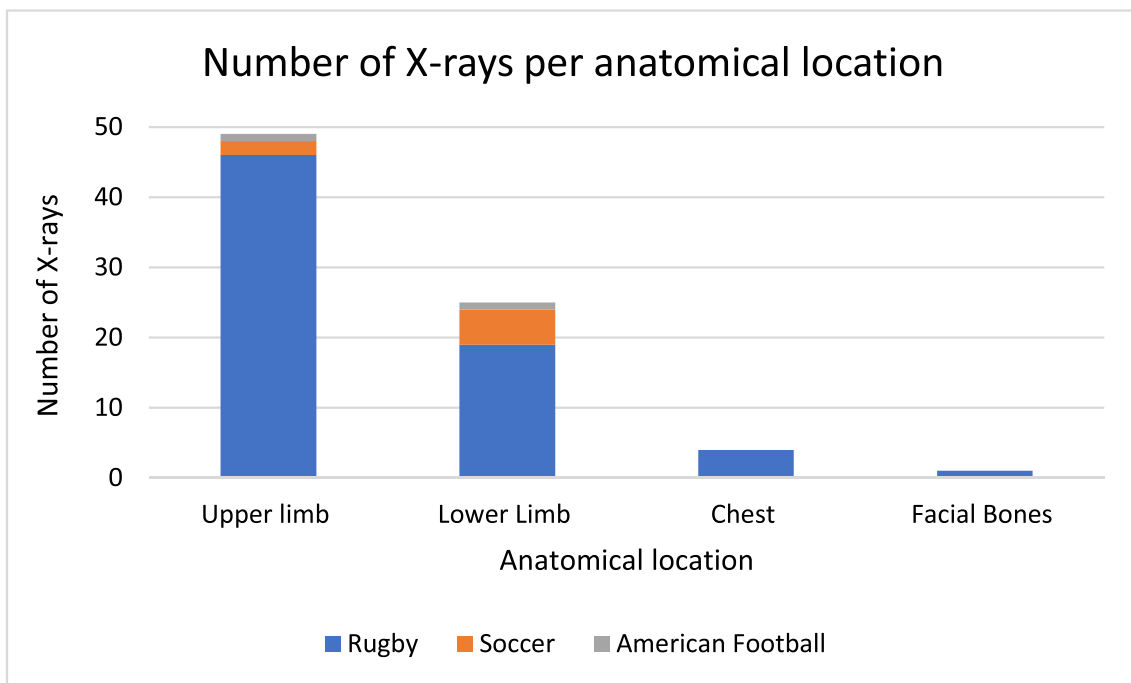


Fig. 5 Number of x-rays per anatomical location

variable environmental conditions. Extremity cone beam CT is an attractive alternative to x-rays for assessment of osseous injuries as it can provide a high resolution and low-dose study using a small footprint. However, the cost, transportation, machine maintenance, and room conditions (humidity and temperature) are current limiting factors in the utilization of cone beam CT within the PSRU [8].

In addition to providing a pitch side diagnosis of an in-play injury, the PSRU allowed players, in particular visiting international teams, to avoid visiting local emergency department. High-profile sporting players attending local emergency departments can be challenging, with regard to security and privacy concerns and navigating road closures on match days. The availability of medical diagnostic information is sometimes a key feature of a manager's post-match press conference and pertinent information on decisions regarding what is publicly communicated can reduce pressures on players.

There are limitations to this study. The described PSRU was equipped to primarily assess osseous trauma, thus soft tissue injuries, common in contact sports, may not have been identified. If soft tissue injuries were suspected clinically by the on-field medical staff, the athlete was transferred to our associated university hospital 5 km from the stadium for cross-sectional imaging, most commonly MRI. The expense of providing cross-sectional imaging such as MRI or CT in a PSRU is considerably higher and requires more complex staffing requirements. Provision of mobile services, both CT and MRI, brought to the respective stadium on match day can obviate some of these difficulties and is being trialed at other national stadiums around Europe and in major sporting stadiums in North America at the time of writing this review. The recent addition of an ultrasound unit within the PSRU at the Aviva stadium aims to improve detection of soft tissue trauma and decrease the requirement for both CT scanning and MRI. Finally, we did not have access to imaging or radiology reports of players who had post-competition imaging outside the PSRU, as many players were international players or not based locally.

Conclusion

The PSRU at the Aviva stadium is well utilized and allows for a cost effective and rapid diagnosis of osseous injuries sustained on the field of play. It provides a useful adjunct to the pitch side clinical assessment by medical staff, giving a privacy, security, and strategic advantage to patients. Consideration should be given to installing similar PSRUs at major sports stadiums around the world.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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