Emergency Radiology
https://doi.org/10.1007/s10140-023-02183-0

ORIGINAL ARTICLE

Role of emergency teleradiology in a mass motorcycle event: the experience of the 2021 International Six Days of Enduro (ISDE)

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Received: 2 October 2023 / Accepted: 1 November 2023

Abstract

Purpose Provision of healthcare support at mass gathering sporting events is of paramount importance for the success of the event. Many of such events, like motorsports, have been increasingly taking place in remote and austere environments. In these settings, the use of first-line diagnostic tools, such as point of care ultrasound and portable X-ray, could aid in definitive care on the field for patients with minor trauma while also ensuring fast access to the appropriate level of care for patients requiring hospitalization.

Methods As part of the ISDE 2021 medical response plan, a field hospital equipped with portable digital X-ray and telemedicine was established. Data on patient admission, triage, treatments, diagnostics, and outcomes were collected for analysis.

Results During the 6-day competition, 79 patients sought medical care at the field hospital, with traumatic injuries accounting for 77% of cases. Of these, 47 were athletes and 32 were non-athletes. The majority (91%) arrived spontaneously, while 9% were transported directly. Upon admission, 68 patients were triaged as non-urgent (code 3) and 11 as urgent (code 2). Of those admitted, 69 received treatment and were discharged at the field hospital, while 10 were transferred elsewhere. Notably, four patients had major trauma, two had isolated fractures, and one needed a CT scan after losing consciousness. Overall, 29 missions were conducted on the race field, including 13 primary transports to local hospitals and 6 to the field hospital. Primary transport was primarily due to major trauma. Among 31 patients who had radiological exams, 11 (35.5%) had traumatic injuries. Of these, 5 were treated with braces and casts and discharged without hospitalization, 3 were advised for post-event care, and 3 were hospitalized. In contrast, patients with negative X-rays received on-site treatment, with 7 able to continue competing.

Conclusions In summary, the successful implementation of portable X-ray machines and teleradiology at remote and austere high-risk sporting events holds great promise for enhancing on-site medical capabilities, allowing clinicians informed decisions, avoiding unnecessary hospitalization, and allowing athletes to continue with their competition. Provided that challenges related to cost, safety, connectivity, and power supply are effectively addressed.

Keywords Portable X-ray · Sporting events · Traumatic injuries · Medical capabilities · Remote settings · Radiation safety · Telehealth · Telemedicine · E-health · Remote care · Teleradiology

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Published online: 10 November 2023

Introduction

Provision of healthcare support at mass gathering sporting events is of paramount importance for the success of the event. Many of such events, like motorsports, have been increasingly taking place in remote and austere environments. These environments are often characterized by harsh conditions, difficult to access location, and lack or minimal access to hospitals. On the other hand, these events are often rich with medical encounters, especially of traumatic nature [1–3]. As a consequence, the ideal medical system for these events is the one able to treat most cases on site. Event medical services are open to athletes, staff members, and the wider general public. There are several advantages to this strategy including discharging athletes directly from the event site and allowing them to continue in their competition without wasting time, prevent excessive workload on local hospital facilities, and coordinate with the local/regional emergency medical system in case of a mass casualty incident. The healthcare system should also be integrated in and cooperate with all stakeholders and organizations involved in the event planning and delivery [4–6]. In sporting events where the most common condition is trauma, the system must provide the best possible care for both major and minor trauma patients. The use of first-line diagnostic tools, such as point of care ultrasound and portable X-ray, can aid in definitive care on the field for patients with minor trauma while also ensuring fast access to the appropriate level of care for patients requiring hospitalization [7]. Acute off-road motorbike-related pathologies have been poorly studied, but musculoskeletal injuries are the principal medical concern, mainly of the extremities. A prospective analysis from four previous International Six Days of Enduro (ISDE), the largest off-road motorcycle world championship further subdivides them into ligamentous (47%), fractures and dislocations (46%), and muscular strains (7%) [1]. These injuries are minor to moderate in 98% of cases, with abbreviated injury scale (AIS) grades 1 and 2 [8]. The aforementioned traumatic injuries require a radiological evaluation to be assessed and treated. Furthermore, to our knowledge, the literature discussing on-site radiology in sports events is scarce. This study aims to share our experience from the 2021 ISDE held in Italy, highlighting the advantages of utilizing a mobile radiological service in conjunction with on-call teleradiology reporting and on-site orthopedic consultations, including casting, to efficiently manage trauma cases, prevent hospitalization, and ensure the continuity of athletes' participation in a multi-day professional sporting event.

Materials and methods

Study population and event description

The International Six Days of Enduro, usually referred to as the "Olympics of Motorcycling," is a 6-day long strenuous motorbiking competition held on open to traffic dirt-road and selected dedicated motocross circuits [9]. Over the 6 days and upwards of 1250 miles, a rider must contend with strict rules about time allowances and restrictions on mechanical replacements, carrying out his or her own motorcycle repairs. ISDE 2021, originally planned for 2020 but postponed due to the COVID-19 pandemic, took place between August 30th and September 4th, 2021, on a vast rural territory between Lombardy and Piedmont regions, Italy, involving 648 riders and a wide range of workers and members of the public. The standard personal protective gear worn by competitors of this event, coupled to the relatively low average speed 40 km/h (25 miles/h) compared to other motorsports, provided a relatively higher level of protection from injury than that seen in any other population of motorcycle riders [1].

Emergency medical service description

The emergency response was coordinated by a Mass Event Command Unit (MECU) deployed on-site, which coordinated ten mobile critical care teams deployed around the competition sites, each composed of a critical care doctor and an emergency registered nurse; five basic life support ambulances; and four off-road vehicles, one for every race site. The MECU is a technological vehicle equipped like a mobile control room with communications capacity, dispatch software, electronic patient records, and telemedicine. Specifically for the ISDE, the MECU was staffed by a command and coordination team composed of one chief medical officer, one attending orthopedic physician available for consultations, two critical care nurses (as emergency call receivers), one emergency medical technician as dispatcher, one emergency medical technician from the local emergency medical service (EMS) as point of contact with local EMS agency, and one critical care attending on call for major trauma, all of whom had previous training in mass gathering management and medical care. During the event, a cardiologist and a radiologist were on call, as part of the telemedicine program. If deemed necessary, helicopter emergency medical service (HEMS) transfer service was also available.

All medical staff members were attending level. All radiologists were attending, as this is a requirement by Italian law.

Field hospital and X-ray system description

A field hospital was set up in the paddock area with nine beds divided as follows: six minor and observation beds, two emergency and critical care beds, and one isolation bed. In particular, due to the likelihood of trauma-related injuries in this event, the presence of a critical care physician and an orthopedic surgeon was guaranteed at all times. The facility was equipped with a portable X-ray system (Fujifilm FDR Xair®), as illustrated in Fig. 1. The X-ray unit is compact and lightweight, measuring approximately 30 × 26 × 14 cm and weighing 3.5 kg. It resembles a typical dental X-ray set and features a fixed anode X-ray tube. The unit can produce X-rays with voltages ranging from 50 to 90 kV in 2 kV increments and current settings between 0.2 and 2.5 mAs in 12 steps. The flat panel detector was the multi-layer FDR DR-ID1201SE (D-EVO II G35; Fujifilm Corporation, Japan). The exposure size is 42.7 cm × 35.1 cm with a reading grayscale level of 16 bit/pixel and a pixel pitch of 150 µm. The detector is equipped with integrated image processing software that reduces the pixel pitch from 150 to 100 µm. To ensure portability and convenience, the unit includes an integrated lithium polymer battery with a capacity of 11.1 V and 1450 mAh. When fully charged, the battery allows the unit to acquire up to 100 X-ray images, lasting approximately 4 h on standby mode.

Fig. 1 Images of the portable X-ray system that was used during the event (image depicting staff members acting as patients)

Power was provided by a standard 220-V; 16-A supply from the local electrical grid. As a precaution, there was a diesel generator available on-site for backup power generation if needed. The X-ray unit is equipped with an adjustable light beam and collimators, enabling precise targeting of the X-ray area. Users can easily select and view technique factors on the unit's display. For versatile positioning, the unit has a fixing point on the underside, allowing it to be mounted on a tripod or stand. The X-ray exposure is initiated from the end of an exposure cable, which can be stored with the main unit or carried separately. Additionally, a separate charger and cable are provided for battery charging. This setup enables the system to perform diagnostic imaging for various views, including the chest, pelvis, and extremities. Overall, the X-ray unit provides a portable and efficient solution for obtaining quality X-ray images for medical diagnostic purposes. A previous study comparing the unit used in this event with typical units located in permanent installations did not find any difference in image quality and diagnostic power [10]. The same study investigated in-depth emission parameters and reported leakage doses for the study machine. They found consistently well below threshold doses for participants and health workers (especially for the radiographers, the leakage doses were below international guidelines on the stochastic limits for the occupational exposure of < 20 mSv/year over 5 years) [10]. Nevertheless, in our setting, the machine location was optimized by using it far away from any other patient or healthcare workers, and the technicians wore a protective lead vest. When appropriate patients were shielded. The X-ray unit was operated by a radiographer on site who also operated the telemedicine software. The radiographer on site was in charge of technical and quality control issues, liaising with the radiologist and medical physicist available remotely. The picture archiving and communication system (PACS) used was Synapse® by Fujifilm. Internet connectivity was ensured through the use of two redundant, load-balanced 5G hotspots. These hotspots were connected to the radiology computer through a router and switch. Additionally, a backup connection through Starlink, which relies on satellite internet, was also in place. All connections were protected through a dedicated secure virtual private network (VPN) and firewall. The radiographer operating the machines could visualize the images on the onsite radiology computer and send them to the remote emergency radiologist on call. The radiologist received the consult request digitally and within a short time provided a report. If there was a special concern, the radiologist was available by phone for further discussion with the on-site clinicians. In addition to the X-ray machine, an ultrasound machine (Esaote MyLab®) and blood gas analyzers (VchemiS®, Nexus IB10, OPTI CCA-TS) were available as additional diagnostic tools.

Triage system

Patients could either self-present to the field hospital (i.e., peak times in the evening after the races of the day were over) or transferred from the various competition sites. Patients requiring medical care from outside the paddock area were discussed from the field teams with the MECU coordination team. For the triage, a scale consisting of 3 levels was applied: priority 1 (immediate), priority 2 (urgent), and priority 3 (non-urgent). This was selected based on anatomical, physiological, and mechanism factors. Rescue calls classified by the on-scene medical personnel as priority 1 or 2 were directly managed by the medical doctor present in the MECU, and the decision had to be made between a primary transfer to the local major trauma center (60–90 min by ambulance), local trauma unit (30–60 min by ambulance,) or a technical pit stop to the field hospital. Trauma patients with a priority code 3, without traumatic brain injury or thoracic and abdominal trauma, were electively transferred to the field hospital.

Data collection

All patients were registered in our electronic patient care recording (ePCR) system. Data of interest were selected retrospectively by members of the medical team. The following data were collected: date and time of admission, the triage code at admission and discharge, the modality of access (spontaneous or via ambulance), patients' category (whether athlete or not), complaint, treatment, diagnostic imaging results, and diagnosis. The outcome at discharge was of particular interest, being the possibility of either continuing the race or dropping out (in the case of a non-athlete patient, the ability to continue their role in the competition) or the admission to a hospital for further care.

Results

During the event, a total of 79 patients were admitted to the field hospital. Trauma was the most prevalent condition, accounting for 77% of the total admissions. The remaining 23% were medical cases including nausea and vomiting, fever, allergic reactions, skin rashes, and sore throats. Of the admitted trauma patients, 47 were athletes and 32 were non-athletes (either staff members or members of the public). The majority of patients, 72 (91%), presented spontaneously to the field hospital while the remaining 7 (9%) were transported from the race area. Thirteen patients were transferred directly from the race to a local emergency department (either major trauma center or trauma unit depending on severity): 9 major traumas, 3 exposed fractures, and 1 ophthalmic injury. At field hospital admission, 68 patients were triaged as code 3 (minor) and 11 as code 2 (moderate). Of those admitted, 69 patients were treated and discharged at the field hospital, while 10 were admitted to a local emergency department for further treatment. Four patients reaching the field hospital were considered major trauma with anatomical injuries, two needed orthopedic treatment for isolated fractures of multiple long bones, and one needed CT scan after a loss of consciousness. The latter 7 patients self-presented to the field hospital. No unstable patients reached the field hospital. A total of 31 patients underwent radiological examination through the portable device. Eleven (35.5%) of them were diagnosed with a traumatic injury. Among the patients with a positive X-ray for injuries, 5 were treated by the orthopedic surgeon on site with braces, casts, and other orthopedic devices and discharged without hospitalization, 3 were advised to seek further medical care when they returned home, and 3 were hospitalized. None of them could continue the competition. Among the patients with a negative X-ray, 10 were treated on site by the orthopedic surgeon with stabilization, analgesia, ice, or suturing. Three were advised to seek further medical care when they returned home, and 3 were hospitalized. Seven could further continue the competition. Finally, although not the object of the study, it is worth recommending the presence of an ultrasound machine which complements the diagnostic capacity of X-ray. Due to the absence of an on-site radiologist, the use of the ultrasound was intended only for point-of-care evaluations. Our main uses were for extended focused assessment with sonography for trauma (E-FAST) performed by the critical care physicians or musculoskeletal sonography performed by the orthopedic surgeon.

Discussion

This study is exploring the potential benefits and feasibility of deploying portable X-ray machines in large-scale sports events, where traumatic injuries are the main concern. The literature on the topic is scarce. A small pilot study successfully explored the usage of portable X-ray machines in novel settings such as the patient home or care home [11]. In England, in a parallel study at the beginning of the COVID-19 pandemic, the X-ray response team, composed of a paramedic, a radiographer, and an emergency care physician, was instituted to provide home care with the goal of reducing viral transmission risk [12]. These studies have common traits with our experience, showing the potential benefits of bringing radiological and traumatological care outside the hospital walls. However, as far as we are aware, our study is the first to explore the benefits of deploying a team of specialists, with a portable X-ray machine, in a remote area for a large-scale event with an increased probability of trauma. We emphasize that the radiological apparatus should not be viewed independently but rather as a weapon integrated into the arsenal of a multidisciplinary team composed of critical care/emergency physicians, orthopedic surgeons, radiology technicians, radiologists, and medical logistics experts.

This small pilot study showed several advantages. The patients in the study were elite athletes who had dedicated their whole lives to training. None of the twenty negative exams underwent hospitalization, saving a person who often does not speak the local language to spend hours in hospital and vice versa saving the emergency department from further workload.

Among the cases negative for fracture, ten were discharged after undergoing treatments such as suturing, analgesia, stabilization, and ice. In this highly competitive context, it also meant that after having identified the entity of the issue, with an X-ray negative for fractures, the athlete could decide to continue the race, as it had been the case with seven individuals.

Conversely, among the eleven patients with an X-ray positive for fractures, five underwent hospital-level treatments such as casts, braces, suturing, analgesia, stabilization, and ice on site. The availability of the X-ray machine also allowed post-reduction and casting X-ray controls. Three were hospitalized after stabilization and analgesia since the appropriate treatment was surgical. Notably, no individual within the positive category continued the race. We consider this an important element, since in high-level elite environments, athletes' global investment is elevated, and abandoning a race such as a the World Cup may negatively affect their career. Providing on-site diagnosis allows the physician to make informed clinical decisions, sustained by an objective test such as the X-ray, allowing a proper delivery of the news to the athlete, alleviating the apprehension about potentially having to exit the competition based solely on speculative diagnostic assumptions prematurely.

Some patients with both negative or positive X-ray only received medical advice. This represents an additional service to the patients, which as previously mentioned, were often internationals. It refers to a subgroup of patients who had either a negative (3 individuals) or a positive (4 individuals) X-ray who were deemed stable enough after initial treatment to seek care according to their preference. In this context, it often meant allowing the patient to reach back home and undergo hospitalization there, which encompasses several advantages. Namely, allowing for potentially more affordable treatments due to insurance coverage or government support, easier access to healthcare facilities and specialists, reducing logistical challenges, better adherence to follow-up care, crucial for ongoing medical conditions, clear and effective communication with healthcare providers in the native language, the continuity of care by accessing complete medical history, aiding informed decisions and avoiding duplication of tests, overall reduced risks due to familiarity with the healthcare system and procedures, and, importantly, a familiar environment and support system, which positively impacts emotional well-being. Timely diagnosis and prompt medical intervention have a direct impact on patient outcomes. By having access to on-site X-ray capabilities, medical teams can significantly reduce the time between injury occurrence and treatment, potentially minimizing short- and long-term complications. The relieving effect of the portable X-ray is also evident on the local healthcare facilities, which at the time had also been burdened by the pandemic. A transfer to the hospital meant an additional load for the local healthcare, long waiting times, the potential infection by SARS-CoV-2, and with a more informed clinical decision transfer occurred only when strictly necessary. It is crucial to specify that major traumas and in general life-threatening illnesses were directly transported to a hospital facility, as it was stated in the event medical management plan, instead of being diverted to the field hospital for X-rays and other diagnostics that would have delayed definitive care. Since the machine can obtain high-quality chest X-rays, we could speculate that in the event of 1 week, with also a conspicuous number of frail individuals in the public, the machine could have been useful in diagnosing non-traumatic diseases such as pneumonia.

Limitations of our study

While the initial results showed promise and suggested positive outcomes, we must acknowledge that being a small pilot study, it carries inherent limitations that need to be carefully considered. The limited sample size was necessary for feasibility, but it may not fully represent the diversity of patients and medical conditions encountered in real-world scenarios. As a result, the generalizability of our findings to a broader population may be compromised. Additionally, the study's design may not have accounted for all potential confounding factors, and the observed results could be influenced by chance variations due to the small sample. To establish the true effectiveness and safety of the intervention in clinical practice, it is imperative to conduct larger, well-controlled clinical trials. One aspect, in particular, that has to be addressed in further research is a cost–benefit analysis, which was beyond the scope of this pilot study.

Feasibility and challenges

A primary challenge revolves around the costs associated with procuring and maintaining portable X-ray machines. These devices can be expensive, and the initial investment may present a significant financial burden, especially for smaller sports events with limited budgets.

Additionally, ongoing maintenance, calibration, and servicing costs must be considered to ensure the equipment remains in optimal working condition. Finding cost-effective solutions or exploring partnerships with healthcare organizations and sponsors could be potential avenues to mitigate this challenge. In this scenario, a solution could be to allow the athlete to stipulate an event-specific insurance that covers also the radiological diagnostics.

Moreover, a broad cost–benefit analysis should not only explore beyond the element of direct monetary cost but also should include the savings that this intervention allows on public healthcare (transportation, hospital staff, and facility utilization) plus the priceless implications for the patient's quality of life.

Another critical concern relates to radiation exposure and the need for robust radiation safety policies. Operating portable X-ray machines requires adherence to strict safety protocols to minimize potential health risks to both patients and medical personnel. This is even more important in field medicine, where the risk of overlooking capital aspects is greater and the facility, the field hospital, is no more than a tent. Legal and deontological aspects, such as informed consent, should be adapted to this setting.

Ensuring that the X-ray machine meets safety standards and that operators are well-trained in radiation safety measures is essential. Collaborating with radiation safety experts and regulatory authorities can aid in developing comprehensive policies to govern the use of portable X-ray machines and mitigate radiation-related risks.

In addition, the implementation of telemedicine through WiFi connectivity adds another layer of complexity. Reliable and secure internet access may not always be readily available in remote event locations, hindering the transmission of X-ray images to off-site specialists for consultation. Establishing a stable WiFi network or exploring alternative communication methods, such as satellite-based solutions, becomes crucial to enable seamless telemedicine capabilities. Additionally, ensuring data privacy and cybersecurity measures are in place to safeguard patient information during transmission is of utmost importance.

A significant challenge faced in remote motorbike events is the availability of a consistent and reliable power supply to operate portable X-ray machines. Traditional power sources may be limited or entirely absent, necessitating the use of alternative power solutions like solar panels, battery packs, or portable generators. Evaluating the energy requirements of the X-ray equipment and implementing efficient power management strategies can help maximize its use in resource-constrained settings. Moreover, it is essential to select a compact, lightweight, and durable machine capable of withstanding the demands of outdoor settings.

Conclusion

In conclusion, the successful implementation of portable X-ray machines and teleradiology at remote and austere high-risk sporting events holds great promise for enhancing on-site medical capabilities, allowing clinicians informed decisions, avoiding unnecessary hospitalization, and allowing athletes to continue with their competition.

Acknowledgements We thank Dr. Mattia Balboni for coordinating the production of the figure for this paper.

Data availability Due to privacy and ethical concerns, neither the data nor the source of the data can be made available.

Declarations

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

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