Prospective Evaluation of Point-of-Care Ultrasound at a Remote, Multi-Day Music Festival

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Abstract
Introduction: Point-of-Care Ultrasound (POCUS) has become an important diagnostic tool for hospital-based clinicians. This study assesses the role of POCUS at Pemberton Music Festival 2016 (Pemberton, British Columbia [BC], Canada), a remote mass gathering where physicians face limited resources, complex disposition decisions, and a dynamic clinical environment.

Objectives: This study prospectively evaluated the impact of POCUS on patient diagnosis, management, and disposition based on the self-report of the study physicians. The authors hypothesized that having ultrasound available for use would aid in diagnostic and management decisions and would reduce the need to transfer patients off-site to other health care facilities, reducing impact on the acute health services in the host community.

Methods: A handheld ultrasound was available for use by physicians in the main medical tent. All participating physicians self-reported their training and comfort using POCUS. After each POCUS scan, physicians completed a survey and recorded the indication for use, scans performed, and impact on patient diagnosis, management, and disposition.

Results: In total, POCUS was used on 28 of the 686 patients treated in the main medical tent; POCUS was reported to narrow the differential diagnosis in 64% of cases and altered the working diagnosis in 21% of cases. Its use changed the management plan in 39% of patients. Its use was reported to reduce the burden on broader health care resource utilization in 46% of cases and prevented ambulance transport off-site in 32% of cases (nine cases in total). This corresponded to an absolute risk reduction of 1.3% for the percentage of patients transferred to hospital (PPTH; relative risk reduction of 53%).

Conclusion: Physicians reported that POCUS improved the diagnosis, management, and disposition of select patients at a remote, multi-day music festival. Also, POCUS reduced ambulance transfers off-site and reduced the perceived burden on broader health care utilization.

surrounding communities to service the unmet needs. The ripple refers to the disruption of regional services beyond the local geography of an event, caused by the addition of an event population above and beyond the usual baseline level of service in that community. Although previous efforts to characterize the impact of mass gatherings on the health care resources of host communities have been made, evidence-based consensus on specific strategies to mitigate this burden are still an area of research.

Pemberton Music Festival is held annually (2008, 2014-2016) in Pemberton, British Columbia (BC), Canada, a rural community of approximately 5,000 year-round residents located 150km north of Vancouver, BC. Pemberton has a small, six-bed community health clinic that operates 8:00AM to 10:00PM daily with a Family Medicine physician on-call, basic laboratory testing, and x-ray department. There are no ultrasounds, computed tomography (CT) scans, or inpatient facilities. The 2016 festival attracted a cumulative attendance of approximately 180,000 paying attendees plus support staff, volunteers, and vendors over the five days of the festival. During its peak, the Pemberton Festival grounds had a population of over 40,000, an eight-fold increase in population over the community’s baseline. For perspective, during the festival weekend, Pemberton’s population was approximately equal to the 10th largest city in the Province. This drastic surge in population highlights the importance of comprehensive, multi-stakeholder, pre-event planning to manage the predictable and life-threatening clinical presentations faced by the on-site medical team to help prevent over-use of local health care infrastructure.

In recent years, the use of Point-of-Care Ultrasound (POCUS) has expanded across many medical specialties and has become a core element of the practice of Emergency Medicine. In contrast to consultative sonographic investigations performed by ultrasound technicians and then later interpreted by radiologists, POCUS can be performed by any trained clinician and provides an immediate look into underlying anatomy and pathophysiology. In recent years, the body of literature surrounding the use of POCUS has grown substantially, and its use has been described in a host of different settings, including the emergency department (ED) and hospital wards, prehospital environment, on the battlefield, in rural and remote settings, during expedition medicine, as well as aboard the International Space Station. Currently, POCUS is regularly used to assess for intra-abdominal bleeding, fractures, soft-tissue foreign bodies, ocular pathology, hemothorax and pneumothorax, intracardiac pregnancy, deep vein thrombosis, pericardial effusion, and procedural guidance.

This study provides a detailed description of the use of POCUS at a remote, multi-day music festival and discusses how its use impacts patient care as well as broader health care resource utilization. This research explores how POCUS may help improve emergency response at mass gatherings and potentially reduce the effect mass gatherings exert on their host community.

Methods
This prospective observational study was approved by the University of British Columbia Research Ethics Board (REB; Vancouver, BC, Canada).

A recruitment email outlining the study was sent to physicians scheduled to work during the festival. Most of the physician study participants were either practicing emergency physicians, or residents in a recognized Emergency Medicine or Family Medicine training program. This was followed by an in-person interview to obtain informed consent prior to their first shift. At the time of consent, a structured survey was administered by a co-investigator (RP or CS) to determine the physicians’ previous experience with POCUS. Physicians self-reported as novice, intermediate, or advanced sonographers. Novice sonographers were defined as those clinicians with introductory-level training who used select scans occasionally in their regular clinical practice. Intermediate sonographers were defined as those clinicians comfortable with a large number of scans and who regularly integrated POCUS into their practice. Advanced sonographers were defined as those clinicians that had extensive training in ultrasound, some with fellowship specialization, and for whom POCUS was an integral part of their day-to-day practice.

POCUS at a Remote Music Festival

Once on-site, a handheld GE Healthcare V-Scan Dual Probe (linear and phased array probes; GE Healthcare; Fairfield, Connecticut USA) was available for use by all physicians on-duty in the main medical tent, at their discretion. Upon completion of any scan on patients aged 16 or older, study physicians were approached by a research assistant and encouraged to complete a structured survey investigating pre- and post-POCUS diagnosis, the indication for scanning, which scans were performed, pertinent findings, and how POCUS impacted the diagnosis, management, and disposition of patients (Supplementary Figure 1; available online only). Fields for free-text comments were also provided and physicians were encouraged to elaborate on their answers.

Data were input and analyzed using Microsoft Excel 2013 (Microsoft Corp.; Redmond, Washington USA), and descriptive statistics were reported using number and proportion, where appropriate.

Results
In total, 17 of the 24 (71%) physicians working at Pemberton Music Festival 2016 consented to be part of the study and reported their experience with POCUS as follows: nine novice sonographers, six intermediate sonographers, and two advanced sonographers.

At the festival, the estimated cumulative attendance was approximately 180,000 attendees (30,000 – 40,000 per day). A total of 2,689 patients were treated by medical staff on-site (patient presentation rate per 1,000 attendees = 14.9), 686 of whom were treated in the main medical tent where POCUS was available for use. In total, POCUS was used on 28 different patients: five by novice sonographers, 11 by intermediate sonographers, and 12 by advanced sonographers.

Table 1 highlights the indications for POCUS. The most common ultrasound indications were abdominal pain, gynecologic complaints, dyspnea, and musculoskeletal, respectively. While there were only 28 patients, a total of 37 indications were documented as some patients had multiple indications.

Table 2 describes the POCUS scans performed by the study physicians. The Focused Assessment with Sonography in Trauma (FAST) exam, global cardiac activity, and lung ultrasound were the most commonly performed scans, respectively. Multiple scans were performed on the same patient as per the discretion of the study physician.

Table 3 illustrates the impact of POCUS on both diagnosis and management. In 22/28 cases (79%), POCUS was reported to aid in diagnosis, narrowing the differential diagnoses in 18/28 (64%) cases.
Its use actually changed the working diagnosis in 6/28 (21%) cases. Its use changed the management plan in 11/28 (39%) of the patients.

Physicians were surveyed on the perceived impact that POCUS had on reducing broader local health care utilization (Table 4). They reported that POCUS reduced the impact on the host community health resources in 13/28 (46%) cases and prevented the need for ambulance transport to a higher level of care in 9/28 cases (32%). As eight patients were transferred off-site, and POCUS was reported to prevent transfer in nine cases, the projected number of transfers without POCUS available would have been 17. Thus, the projected PPTH would be 17/686 (2.5%) of those patients treated in the main medical tent. The actual PPTH with POCUS on-site was 8/686 (1.2%) resulting in an absolute risk reduction of 1.3% or relative risk reduction of 53% with the use of POCUS. The festival's cumulative transfer-to-hospital rate was 0.044 per 1,000 attendees.

A description of the specific cases where the use of POCUS prevented transport is outlined in Table 5. These cases included ruling out pneumothorax, intra-abdominal bleeding, cardiac pathology, and to confirm a fracture that otherwise would have needed an x-ray.

### Discussion

**Impact on Patient Care**

Currently, POCUS use in hospitals has expanded in recent years and is an integral part of the diagnostic arsenal for many acute care and Emergency Medicine physicians.9–13 The medical tent at a large music festival provides a range of medical care that is similar to a community ED, and the indications for POCUS in the study were similar to those encountered in an ED.14 In the hospital, POCUS has well-established parameters, and a large body of experience in refining diagnostic and management decision making.14,15 Considering the similarities between a medical tent and ED, literature supporting POCUS use in the ED is certainly relevant to a music festival setting. Furthermore, at a remote music festival where additional challenges face clinicians, including limited resources, suboptimal lighting, high levels of ambient noise, and a large proportion of intoxicated patients, it is not surprising that physicians reported POCUS to aid in diagnosis and management in the majority of cases it was used.

The two specific clinical scenarios that physicians reported POCUS to be most valuable were when there was a concern for pneumothorax or occult intra-abdominal bleeding. These life-threatening conditions can be difficult to diagnose with history and physical exam alone, but they can be accurately diagnosed with POCUS.17–20 In the cases where pneumothorax or intra-abdominal bleeding were of concern, physicians reported that a negative scan made them feel comfortable observing patients on-
site, thus preventing an urgent transfer to definitive care in the rural host community, or a further transfer to an urban center. Both the FAST exam and pleural ultrasound are taught in many introductory POCUS training courses, suggesting that the benefit from having ultrasound on-site is available to all trained clinicians, not simply experts.

In this study, there was a wide range of self-reported experience with POCUS. The majority (82%) of the POCUS scans performed at the festival were done by the minority of clinicians (47%) who identified themselves as intermediate or advanced POCUS practitioners. This result may indicate that the novice POCUS clinicians found ultrasound less valuable than more experienced clinicians. Alternatively, novice clinicians’ workflow may not include POCUS as a standard tool compared to those who are more experienced and facile with it. Another explanation may be that novice clinicians are less confident in accepting POCUS as definitive, and thus directly transfer patients for definitive imaging without the use of POCUS. Despite this discrepancy, clinicians with all levels of experience endorsed ultrasound as a valuable tool in refining the diagnosis, management, and disposition of patients.

Impact on Local Resources
Mass gatherings of any size have the potential to burden multiple domains of host community resources, including emergency health care, emergency response services, sanitation, food services, and transportation. These effects extend beyond the immediate vicinity of a given event, and can impact nearby municipalities, regional infrastructure, and in some cases, surrounding provincial/state or even national resources. Transfer of the most acute or unstable patients, or those requiring more definitive diagnostics or management is inevitable, but any attempt to prevent unnecessary transfers off-site is nonetheless important.

The use of POCUS at Pemberton Music Festival was reported to prevent nine transfers off-site. This represented an impressive reduction in transfers considering only eight patients in total were transferred off-site during the duration of the festival. At the festival, the nearest hospital with inpatient facilities is approximately 90-minutes away by road, and the nearest trauma center is two hours by road and at least 35 minutes one-way flight time via helicopter. These distances mean that transfer of an acute patient may require a nurse or physician escort in addition to a paramedic crew, potentially taking away limited resources from the remote festival venue. Furthermore, with only two to three ambulance crews on-site at any given time, transport of even one patient increases the overall risk should another emergency happen during their absence.

More generally, physicians reported that POCUS reduced the broader health care resource utilization in 46% of cases where it was used. This was accomplished through preventing transfers off-site and reducing the need for additional imaging, or unnecessary procedures. As POCUS machines continue to become more portable and less expensive, this modality could prove to be an important measure to reduce downstream health care costs in patients presenting at mass gatherings.

Limitations
Although this research represents an important first step for studying POCUS at mass gatherings, there are some notable limitations. Firstly, the results were based on self-reports of physicians, and due to technical limitations, images were not saved for further review. As well, there was no follow-up of the study patients, making it difficult to determine whether the decision making surrounding POCUS was clinically sound. Furthermore, there may have been an observer effect (Hawthorne Effect) as physicians knew research was underway, perhaps leading them to respond more favorably, as has been reported during research in

<table>
<thead>
<tr>
<th>Did Ultrasound…</th>
<th>Number of Affirmative Responses, N = 28 n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aid in diagnosis?</td>
<td>22 (79)</td>
</tr>
<tr>
<td>Aid in management?</td>
<td>21 (75)</td>
</tr>
<tr>
<td>Narrow your differential?</td>
<td>18 (64)</td>
</tr>
<tr>
<td>Confirm your management plan?</td>
<td>16 (57)</td>
</tr>
<tr>
<td>Exclude a life-threatening diagnosis?</td>
<td>14 (50)</td>
</tr>
<tr>
<td>Change your management plan?</td>
<td>11 (39)</td>
</tr>
<tr>
<td>Change your working diagnosis?</td>
<td>6 (21)</td>
</tr>
<tr>
<td>Prevent an unnecessary procedure or intervention from being performed?</td>
<td>5 (18)</td>
</tr>
<tr>
<td>Result in a new procedure or intervention being performed?</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Change the level of acuity and/or urgency of transport for the patient?</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Confirm a life-threatening diagnosis?</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Table 3. Reported Impact of POCUS on the Diagnosis and Management of the 28 Enrolled Patients
Abbreviation: POCUS, point-of-care ultrasound.

<table>
<thead>
<tr>
<th>Did Ultrasound…</th>
<th>Number of Affirmative Responses, N = 28 n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aid in appropriate disposition?</td>
<td>15 (54)</td>
</tr>
<tr>
<td>At reduce the burden on the broader health care community?</td>
<td>13 (46)</td>
</tr>
<tr>
<td>Change the urgency for obtaining formal diagnostic imaging?</td>
<td>12 (43)</td>
</tr>
<tr>
<td>Prevent the need for transport off-site?</td>
<td>9 (32)</td>
</tr>
<tr>
<td>Prevent the need for obtaining formal diagnostic imaging?</td>
<td>7 (25)</td>
</tr>
<tr>
<td>Did this patient require transport off-site by ambulance?</td>
<td>3 (11)</td>
</tr>
<tr>
<td>Change the level of acuity and/or urgency of transport for the patient?</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Change the receiving hospital?</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Table 4. Impact of POCUS on Patient Disposition and Local Community Health Care Resources
Abbreviation: POCUS, point-of-care ultrasound.
other acute care settings. Moreover, although physicians were reminded to complete data collection forms, research assistants were only present 18 hours per day and some cases where POCUS was utilized may not have been captured. Finally, the population was small and represented a convenience sample, potentially introducing selection bias and limiting generalizability to other mass gatherings.

Conclusion and Future Directions
The use of POCUS at Pemberton Music Festival 2016 was reported to improve diagnosis and management of patients, and also to reduce broader health care resource utilization with an absolute risk reduction for the PPTH of 1.3% (relative risk reduction of 53%). Further research is required to fully characterize the role of POCUS at other mass gatherings, and a future study with patient follow-up and saved ultrasound images would ensure decisions being made using POCUS are clinically sound.

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Author Contributions
All listed authors contributed to the study design, data analysis, and manuscript composition.

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