



Are all after-hours diagnostic imaging appropriate? An Australian Emergency Department pilot study



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HIGHLIGHTS

- This study found that most afterhours, Emergency Department, diagnostic imaging was appropriate.
- This study found that the use of clinical guidelines may enhance patient management.
- This study broadens the limited Australian data associated with inappropriate diagnostic imaging.

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ABSTRACT

Background: This study was aimed at determining the extent to which after-hours diagnostic imaging is appropriate within the case hospital's Emergency Department. This was amid growing concerns of the inappropriateness of some medical investigations within the Australian health-care system.

Methods: After-hours referral data and patient notes were used in reviewing the clinical case. Diagnostic imaging was deemed appropriate if reflective of clinical guidelines, and if not reflective, whether the investigation changed the patient's ongoing management.

Results: Results indicated that 96.37% of after-hours diagnostic imaging adhered to clinical guidelines and was appropriately requested, with 95.85% changing the ongoing management of the patient. The most sought after diagnostic imaging procedures were Chest X-Ray (30.83%), and CT Brain (16.58%), with 99.16% and 98.44 appropriateness respectively. Chest pain (14.49%) and motor vehicle accidents (8.12%) were the leading reason for ordering after-hours imaging.

Conclusion: This study provided an Emergency Department example as it relates to after-hours diagnostic imaging appropriateness. This study found that most after-hours referrals were appropriate.

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1. Introduction

This study was formulated as a pilot study to determine the percentage of appropriate diagnostic imaging within an Australian Emergency Department (ED). Preliminarily, researchers focused on after-hours diagnostic imaging, due to a consensus that a greater percentage of night-time imaging would be more likely to be inappropriate. Results from this study, were thought to provide an indication on whether inappropriate requesting was a problem, before conducting an analysis into day-time requesting trends. The inspiration, for this pilot study was amid the growing concerns around unnecessary medical testing [1–5].

Medical imaging procedures play an important role in patient management and treatment [1]. Diagnostic imaging procedures include: computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), computed tomography (CT), radiographs (X-rays), ultrasounds (US), and nuclear medicine scans. There is interest in the appropriateness of diagnostic imaging [1], and pathology test ordering within Australia [2]. Many radiologists acknowledge that diagnostic imaging is often inappropriately requested by treating clinicians, and that up to a third of all tests are partially or completely unnecessary [3], whereas others have suggested up to 20%–50% are at least in part unnecessary [4,5]. It is recommended that these research percentages be interpreted cautiously, although they do highlight that a least some diagnostic imaging may be inappropriate.

Overutilization has been defined as 'applications of imaging procedures where circumstances indicate that they are unlikely to

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improve patient outcomes' [1]. Inappropriate medical testing has been defined as 'applications of testing procedures which are performed at the wrong time or too frequently to be of value in diagnosis, prognosis, or ongoing clinical patient management' [2]. This study defines inappropriate imaging, as procedures that do not adhere to clinical guidelines, and do not alter the ongoing management of the patient. Inappropriate diagnostic imaging exposes patients and clinicians to potential risks, associated with ionisation [5]. Medical radiation contributes to just over half of the average total radiation dose to residents within the United States of America. This figure has increased since 1980 where it contributed to less than a quarter of the average dose [1]. The reasons for ordering of diagnostic imaging that does not benefit or improve patient outcomes is often multi-factorial and can include: medico-legal malpractice fears [6], diagnostic un/certainty [7], inadequate training [8,9], requests from consulting and referring physicians, increased workloads within emergency care [10], and patient self-referral [1].

After-hours diagnostic imaging is essential in most large hospitals. After-hours diagnostic imaging should only occur if there is a reasonable probability of changing the patient's management [11]. The after-hours clinical findings should also result in after-hours changes in the patients' management, and not at later times or dates. Many emergency physicians, within the United States of America, agree that they should take a greater role in reducing unnecessary or inappropriate tests [12], although little is known about the extent to which after-hour's diagnostic imaging is inappropriate. In a recent study, researchers reported that 85% of emergency physicians, within the United States of America, believed their patients received too many blood tests, urine tests, and imaging tests. Furthermore, 97% acknowledged ordering at least some unnecessary imaging, including CT or MRIs. The main contributors to these figures included fear of missing a low-probability diagnosis, and medical legal fear [10]. It should be noted that Australian clinicians may not have the same pressures to image as American emergency physicians. This difference in location, to the researchers' knowledge, has not been tested within Australia.

The rate of ED presentations within Australia, per 1000 population, increased by 35% between 2003 and 2008. This increase has resulted in an increased demand and bed shortages, with occupancy rates in many hospitals greater than 85%, which has been considered the maximum level for efficiency [13]. Access block has been linked to increased ED waiting times for medical care, which has led to overcrowding [14,15]. It is unknown whether limiting imaging services to after-hours (on-call) specifically contributes to access block within EDs, although it has been documented that EDs are facing issues associated with the impact of access block associated with radiology and pathology referrals [13]. It is believed that minimising inappropriate medical testing may assist in reducing access block.

There has been limited research into the appropriateness of after-hours diagnostic imaging procedures [10,11,16,17]. A study by Wong and Siddle [11] found that most after-hours radiological procedures were justified, although the researchers did acknowledge that certain tests could be reduced after-hours [11]. While research has been completed, there has been little recent attention related to appropriateness of after-hour's diagnostic imaging in EDs. It is unknown whether ED after-hours diagnostic imaging reflects contemporary research findings into inappropriate medical test ordering. As such, the researchers aimed to determine: The extent to which after-hours diagnostic imaging is inappropriate within the case hospital's ED. The outcomes of this pilot study was designed to guide future research into day-time inpatient diagnostic imaging.

2. Methods

2.1. Study setting and participants

A retrospective chart review was performed at the Calvary Hospital Bruce from the 1st of September to the 30th of November 2015 (13 weeks). The Calvary Hospital Bruce is a 250 bed public hospital located in Canberra Australia. The hospital has many services, including an Emergency Department, an Intensive and Coronary Care Unit, Medical and Surgical Wards, a Maternity Unit, a voluntary Psychiatric Ward, and Ambulatory Care and outreach facilities and services. The hospital is a teaching hospital with associations with local universities.

Participants included, all patients requiring after-hours diagnostic imaging, referring emergency clinicians, and imaging and radiology department employees. The referring emergency clinicians included the senior registrars on the evening (15:00–23:00) and night shifts (22:30–08:30). ED employees were unaware of the study.

2.2. Design

After-hours diagnostic imaging was defined as:

- 1) Involving the imaging department's clinical staff:
 - General Radiographer
 - CT Radiographer
 - Sonographer
- 2) Occurring Monday to Sunday any time after 17:00 and before 09:00.
- 3) Involving Emergency Department patients, including Medical Emergency Team (MET) emergencies (within the Emergency Department).
- 4) Not including procedures booked in-hours although completed after-hours.
- 5) Not including staff over-time hours.
- 6) Not including private hospital patients, who were referred from the private hospital for emergency imaging.

The imaging department's clinical 'on-call' staff were required to record the date, the patient medical record number (MRN), the diagnostic imaging exam completed, the requesting doctor's clinical reasoning, and the time they received the call, followed by the time they concluded the examination(s). The requesting doctor's clinical reasoning was gained verbally, at the time of the referral, and via the imaging referral form. This information was used to guide researchers in reviewing the patient notes.

2.3. Data and statistical analysis

The after-hour's referral data was then used by the researchers in reviewing the clinical case via the patient notes, and the hospital's imaging reporting system. Diagnostic imaging exams were deemed appropriate in the following cases:

- 1) If the documented clinical reasoning met the Australasian College for Emergency Medicine clinical guidelines [18], and/or the Diagnostic Imaging Pathways [19].
- 2) If the documented clinical reasoning did not reflect clinical guidelines, it was deemed appropriate if: The procedure changed the ongoing management of the patient:
 - a. The procedure was relevant to the patients symptoms and provisional diagnosis; AND
 - b. A result (positive, or negative) was used to exclude or confirm a suspected diagnosis; AND

Table 1
Top 8 diagnostic imaging tests requested and appropriateness.

Clinical description	Diagnostic imaging (N)	Proportion (%)	Appropriate (%)
Chest X-ray	119	30.83	99.16
CT brain	64	16.58	98.44
Chest mobile	29	7.51	96.55
CT abdomen/pelvis	30	7.77	96.66
US fetal	14	3.60	100.00
US pelvis	14	3.60	100.00
US scrotum	7	1.80	100.00
Shoulder X-ray	7	1.80	85.71

Table 2
Top 8 reasons for the ordering of diagnostic imaging.

Clinical description	Diagnostic imaging (N)	Proportion (%)
Chest pain	50	14.49
Motor vehicle accident	28	8.12
Suspected ectopic pregnancy	17	4.93
Suspected neurological bleed	16	4.64
Suspected torsion	15	4.35
Suspected pulmonary embolism	14	4.06
Fall	12	3.48
Suspected stroke	10	2.90

- c. The investigation assisted clinical decision making, leading to a diagnosis and prognosis; AND
- d. The procedure was not a duplicate, i.e. not an identical matching test performed on that presentation; OR
- e. The procedure made a difference to the course of patient care; patients chart indicated a change in the clinical status of the patient that could potentially dictate the ordering of the procedure at the given stage.

The researchers determined appropriate procedures as those which did reflect current clinical guidelines, and which did alter the ongoing management of the patient. Binary (yes/no) data was collected for both research questions.

All medical records were initially reviewed by one researcher, which was then independently reviewed by another medical clinician. If the two reviewers gave alternative opinions on the appropriateness of the diagnostic imaging procedure, the case was reviewed by a third, independent clinician. Using the above appropriateness criteria, agreement between the two initial reviewers was consistent in all patient cases.

3. Results

There were 14492 ED presentations during the study period, with a total of 7099 imaging tests requested, equalling an average of 2.04 per patient, with 386 completed afterhours (5.44%).

Three hundred and forty five (345) patients were involved in the study, with 386 diagnostic imaging exams reviewed. **Table 1** demonstrates that the most sought after radiological procedures were Chest X-Ray (30.83%), and CT Brain (16.58%), with 99.16% and 98.44% appropriateness respectively. **Table 2** demonstrates that chest pain (14.49%) and motor vehicle accidents (8.12%) were the leading reason for ordering after-hours imaging.

Table 3
Diagnostic imaging appropriateness results.

Month	Patients	Diagnostic imaging exams	Appropriate	Inappropriate	Appropriate (%)	Inappropriate (%)
Sep	116	132	128	4	96.97	3.03
Oct	103	112	105	7	93.75	6.25
Nov	126	142	139	3	97.89	2.11
Total	345	386	372	14	96.37	3.63

Table 3 indicates that 372 of after-hours imaging referrals within the ED are appropriate, reflecting clinical guidelines (96.37%), with 370 changing the ongoing management of the patient (95.85%). The diagnostic imaging exams that did reflect clinical guidelines, although did not change the ongoing management of the patient, included a scapula and finger X-Ray. These tests were deemed appropriate, because they did reflect recommended guidelines. The inappropriate diagnostic imaging exams, included 6 CTs (1.55%), 6 X-Rays (1.55%), 1 Chest Mobile (0.26%), and 1 MRI (0.26%), equalling a total of 14 (3.63%).

Of note, those tests that reflected clinical guidelines (372), 95.85% changed ongoing patient management and/or assisted in clinical decision making. Whereas, those that did not adhere to clinical guidelines [14], 0% changed ongoing patient management and/or assisted in clinical decision making. Specifically, there appeared to be a correlation between guideline adherence, and the medical test altering the patients' ongoing management.

4. Discussion

Diagnostic imaging is important in after-hours EDs. Benefits of diagnostic imaging must be weighed against potential risks, and should be based on evidence-based practice, and benefit the ongoing management of the patient. Imaging that results in a change of patient management, and specifically results in a diagnosis and prognosis; the risk of ionisation is far outweighed by the potential benefits. In saying this, every effort should be made in minimising patient exposure. Specifically, unnecessary investigations must be eliminated without undermining the importance of medical imaging [20].

The results indicated that 3.63% of after-hours diagnostic imaging is inappropriately requested. Results indicate that imaging within the case hospitals ED may not reflect other literature indicating that as much as a third of all tests are partially or completely unnecessary [3,20,21], and may indicate that Australian ED ordering patterns do not reflect general American data [10]. Much of the case hospital's ED referrals appear to be based on rational clinical reasoning, which could be a reflection of the high use of clinical guidelines within Australian EDs. Furthermore, having a restricted on-call after-hours imaging service, may have contributed to the more judicious use of imaging guidelines and investigations within the ED.

Future studies should include additional ED study sites and measure the rate of day-time imaging appropriateness and compare this to after-hours imaging appropriateness, using the methodology discussed in this pilot study. It is hypothesised that day-time imaging inappropriateness will be significantly larger than that of after-hours imaging. One reason for this discrepancy, could be that after-hours imaging requires additional clinical justification, thus resulting in only those deemed clinical appropriate being completed afterhours. If a discrepancy exists between afterhours and day-time imaging then a greater focus on evidenced-based practice and the judicious use of imaging guidelines is required when ordering day-time imaging.

Future research could also compare these results to inpatient after-hours imaging, and broaden the research to include hospital

day time imaging trends. Any data could contribute to the body of knowledge associated with Australian inappropriate medical test ordering.

5. Limitations

The primary limitations of this study included: limited to a single case hospital within one geographical area, and the study timeframe was limited to 3 months.

6. Conclusions

This study provided an ED example as it relates to after-hours diagnostic imaging appropriateness. This study found that most ED after-hours referrals were appropriate, demonstrating that the use of clinical guidelines may enhance patient management. This research project has highlighted the need to continually educate staff on correct ordering practices, specifically those that reflect evidence-based practice.

Availability of data and materials

The researchers would be happy to provide general de-identified research data, on a case-by-case basis. Data will not be made publically available due to hospital policy. Requests for data should be made in writing to the primary researcher. Approval to release data will be provided via the Hospital's Research Ethics Committee.

Ethical approval

This study was approved by the Hospital Research and Ethics Committee (HREC). Number: 6-2016.

Sources of funding

The research did not receive research funding or sponsorship.

Author contribution

Fergus Gardiner: conceived the research, and developed the research design, data collection, and performed the research analysis.

Shaun Zhai: helped conceive the research methodology, performed secondary research analysis, and reviewed and validated the medical record data after initial review, as outlined above.

Conflicts of interest

Fergus W Gardiner would like to disclose that he was an employee of the case hospital during the study period.

There is nothing else to disclose.

Registration of research studies

Researchregistry UIN: 1614.

Guarantor

Fergus W Gardiner accepts full responsibility for the work and/

or the conduct of the study, had access to the data, and controlled the decision to publish.

Consent

“Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request”.

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