








Nurses' knowledge and practice toward computed tomography safety protocols

Conhecimento e prática de enfermeiros sobre protocolos de segurança na tomografia computadorizada

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ABSTRACT

Objective: to assess nurses' knowledge and practice toward computed tomography scan safety guidelines. **Methods:** a cross-sectional study was conducted using a convenience sample of 131 nurses from two government hospitals. Self-designed questionnaire was used to assess nurses' sociodemographic characteristics, knowledge, and practice. Descriptive analysis was performed to evaluate characteristics, correlations were evaluated using Spearman's rank correlation coefficient, and the Mann-Whitney U and the Kruskal-Wallis H tests were used to compare the mean ranks of knowledge and practice scores. **Results:** most respondents were female (91.6%), were aged 20–29 years (57.3%), and had bachelor's degrees (74%). Knowledge and practice levels were 58% and 78.9% respectively. A positive correlation between knowledge and practice was observed among nurses ($r=0.684$, $p<0.001$). No statistically significant differences were observed between sociodemographic characteristics and knowledge and practice scores. **Conclusion:** nurses showed adequate level of practice toward computed tomography scan safety preparations while their knowledge level was deficient. **Contributions to practice:** this study informs the importance of knowledge in guiding nursing practice toward appropriate computed tomography scan safety measures.

Descriptors: Knowledge; Patient Safety; Nurses; Diagnostic Imaging; Nursing Care.

RESUMO

Objetivo: avaliar o conhecimento e as práticas de enfermeiros quanto às recomendações de segurança para realização de tomografias computadorizadas. **Métodos:** estudo transversal utilizando amostra de conveniência de dois hospitais públicos. Foi elaborado um questionário para avaliar as características sociodemográficas, conhecimento e práticas dos enfermeiros. Realizou-se análise descritiva para avaliar as características, e as correlações foram avaliadas através da correlação de Spearman. Os testes U de *Mann-Whitney* e H de *Kruskal-Wallis* foram usados para comparar as médias das pontuações de conhecimento e práticas. **Resultados:** a maioria dos participantes era do sexo feminino (91,6%), de 20 a 29 anos (57,3%), e tinha a graduação como seu nível de formação (74%). Níveis de conhecimento e prática foram de 58% e 78,9%, respectivamente. Houve correlação positiva entre o conhecimento e a prática nos enfermeiros ($r=0,684$, $p<0,001$), mas, sem diferenças estatisticamente significativas entre características sociodemográficas e a pontuação de conhecimento ou práticas. **Conclusão:** enfermeiros mostraram um nível adequado em sua prática do preparo seguro para tomografias computadorizadas, embora seu nível de conhecimento tenha se mostrado deficiente. **Contribuições para a prática:** esse estudo demonstra a importância do conhecimento enquanto guia da prática de enfermagem rumo a um uso melhor das medidas de segurança para tomografias computadorizadas.

Descritores: Conhecimento; Segurança do Paciente; Enfermeiras e Enfermeiros; Diagnóstico por Imagem; Cuidados de Enfermagem.

Introduction

Radiology departments provide a variety of high-quality clinical imaging services. Imaging modalities include ionizing radiation, such as X-rays, fluoroscopy, mammography, nuclear medicine, and computed tomography (CT), and non-ionizing radiation, such as ultrasound and magnetic resonance imaging⁽¹⁾. Computed tomography uses sophisticated X-ray technology to obtain detailed images of the body for diagnostic purposes. It is the preferred technique for emergencies, as it is quick, noninvasive, painless, and precise. Internal injuries and bleeding are revealed easily and quickly to manage severe cases⁽²⁾. Nevertheless, despite their substantial benefits, radiological diagnostic procedures are associated with unavoidable hazards related to radiation exposure.

Bodily tissues are easily visualized by computed tomography imaging using a contrasting medium to image and identify the interface between two adjacent tissues. This allows the radiologist to differentiate normal from abnormal conditions. Iodine-based contrast media can enter the body either by ingestion or by intravenous or intra-arterial injection. Before using contrast agents, the patient should be adequately prepared to prevent side effects. Moreover, contrast agents should not be used in patients with asthma, allergies, or renal and heart diseases⁽³⁾.

Nurses working in radiology departments have crucial roles and responsibilities, as they provide patients with nursing care before, during, and after procedures. Their duties include preparing the material to be used in radiological procedures and observing patients during the procedures and until they are discharged⁽⁴⁾. Therefore, nurses must have sufficient knowledge of the risks of radiation exposure and protective measures to protect themselves and to provide patients with the correct information about radiation protection. They also need to understand the types of contrast medium indications, contraindications, and side effects.

High-quality nursing requires following a cle-

ar plan to help complete the computed tomography scan. This patient preparation plan can be divided into three stages: before, during, and after the scan. Pre CT-Scan Procedure: Check pre-procedural fasting, pre-medication, medical history, and allergy history. Confirm patient information, no pregnancy. Determine the need for oral or IV contrast media. Informed consent must be obtained. During computed tomography Scan Procedure: ensure that the patient wears comfortable, loose-fitting clothes. Inform the patient about the expected duration of the procedure. Provide information about the contrast media; expect a mild pain from the needle puncture. Instruct the patient to report symptoms of difficulty breathing or swallowing, itching, nausea, vomiting, dizziness, and headache. Post computed tomography Scan Procedure: Instruct the patient to increase fluid intake (if contrast media are given). Poor patient preparation may lead to poor diagnostic quality, delays in treatment because of rescheduling, and recurrent exposure to radiation⁽⁴⁻⁵⁾.

Undergraduate nursing students' knowledge and practice toward radiology affect the quality of care delivered to patients and the levels of safe practices, staff satisfaction, and professional development. Nurses can add value to radiological practice by incorporating assessment skills and evidence-based initiatives. Recent research has investigated the experience of nurses outside radiology departments in terms of caring for patients undergoing radiological interventions⁽⁶⁻⁷⁾. Furthermore, previous studies have investigated nurses' knowledge of and practice toward ionizing radiation in several countries, including South Africa, Saudi Arabia, Nigeria, and Finland⁽⁸⁻¹⁰⁾. Prior studies have also investigated nurses' knowledge of and practice toward computed tomography contrast media, as well as toward safety protocols for cardiac computed tomography⁽¹⁰⁻¹¹⁾. It was anticipated that the study will found lack of knowledge and practice among nurses included in the study. The aim of this study was to assess nurses' knowledge and practice toward computed tomography scan safety guidelines.

Methods

This was a cross-sectional study using a self-designed questionnaire. The study was conducted in two government hospitals, King Fahad Specialist Hospital and King Khalid Civilian Hospital, in Tabuk City, Saudi Arabia. Male and female nurses working in different departments of either hospital at the time of the study, of any age, and with any education level and position who were willing to participate in the study were included. Non-Arabic-speaking nurses were excluded. Based on total nurses working in Tabuk city (approximately 2000 nurses), expected sample size need to reach 384 participants. Final sample size was 131 nurses with calculated 8% margin of error. The questionnaire was distributed to 384 nurses in the two hospitals using the convenience sampling method between February and April 2021. Due to the COVID-19 pandemic and the need for infection control precautions, the data were collected electronically using a link to the questionnaire distributed in coordination with the nursing office of each hospital. The prospective participants were adequately informed about the purpose of the study, privacy protection, the potential risks and benefits of sharing information, and their right to withdraw at any time. They were also informed that at least 10 minutes were required to complete the questionnaire. Those who met the inclusion criteria and agreed to participate were asked to click the "agree" option before responding to the questionnaire.

The questionnaire consisted of three parts with closed-ended questions. The first part included items regarding sociodemographic characteristics: gender, age, marital status, education level, position, department, and years of experience. The second part consisted of 15 questions on knowledge of the basic concepts of computed tomography scan systems with "yes" or "no" answers. The third part consisted of 17 items evaluating nurses' practices before, during, and after computed tomography scan procedures. The questionnaire undergoes content validity by 2 radio-

logy experts and 2 nurses' expert in the field at the mentioned governmental hospitals. Reliability testing was performed using Cronbach's alpha for Knowledge part 15-items (0.841) and for practice part 17-items (0.868) indicating adequate level of internal consistency. The cut score to consider sufficient level of knowledge and practice was $\geq 60\%$.

The data were checked for completeness and correctness. Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as means \pm standard deviations (SD). Both Kolmogorov-Smirnov and Shapiro-Wilk tests were significant, indicating non-normal data distribution. The mean knowledge and practices scores were calculated by assigning one point to each correct answer and then calculating the averages. The correlation between the mean knowledge and practices scores was assessed using Spearman's rank correlation coefficient. The relationships between sociodemographic characteristics and the mean knowledge and practices scores were assessed using the Mann-Whitney U test and the Kruskal-Wallis H test. The analysis was performed at a 95% confidence level using the SPSS version 24.0.

Ethical approval was obtained from the Institutional Review Board of the General Directorate of Health Affairs in Tabuk (protocol No. TU/077/021/082, registration No. H-07-TU-077). An informed consent form was placed at the beginning of the questionnaire, and only participants who consented were able to answer the questions. The participants were assured that anonymity and confidentiality would be safeguarded. Participation was voluntary, and withdrawal had no consequences. Consent included using the data for research and publication.

Results

A total of 131 nurses were included in the study. Most of the sample were female. More than half were aged between 22 and 29 years. Their education levels were as follows: Nursing diploma, bachelor's

degree, postgraduate, and other. Most participants were registered nurses interns, assistant nurses, and head nurses (Table 1).

Table 1 – Sociodemographic characteristics of the participants (n=131). Saudi Arabia, 2021

Characteristics	n (%)
Gender	
Female	120 (91.6)
Male	11 (8.4)
Age (years)	
22–29	75 (57.3)
30–39	45 (34.4)
40–49	8 (6.1)
50–59	3 (2.3)
Marital status	
Single	78 (59.5)
Married	53 (40.5)
Education level	
Nursing diploma	24 (18.3)
Bachelor’s degree	97 (74.0)
Postgraduate	7 (5.3)
Other	3 (2.3)
Position	
Intern	30 (22.9)
Assistant nurse	6 (4.6)
Registered nurse	88 (67.2)
Head nurse	7 (5.3)
Experience (years)	
<1	43 (32.8)
1–4	38 (29.0)
5–10	30 (22.9)
>10	20 (15.3)

The distribution of nurses by department ranged between 0.8% in each of labor and delivery and

pediatric medical ward to other departments (28%). Among the respondents, 15.3% worked in emergency departments, and 14.5% worked in intensive care units.

Tables 2 and 3 summarize the knowledge- and practices -related responses. As shown in Table 2, 61.1% of the respondents had previous experience of CT procedures, 81.7% knew that informed consent should be obtained before a procedure, and 93.1% had visited a CT scan room. However, only 45% knew about the hazards of ionizing radiation, and only 47.3% knew about adverse reactions to CT contrast agents.

Almost all (95.4%) nurses explained the CT procedures to the patients and their families. Moreover, most (90.8%) instructed the patients to remove any metallic objects, such as earrings and bobby pins, and to avoid moving during the procedure (Table 3).

In a multiple-response question about nurses’ knowledge about pre-computed tomography procedure for patients’ categories and medical conditions, about 86%, 63%, and 63% of the participants identified pregnancy, allergies, and asthma, respectively, as high-risk conditions. About 44% knew that they should report claustrophobia to the radiologic technologist. Minimal responses for infants (27%), children (22%), stroke (17%), elderly (16%), and Alzheimer patients (12%).

Total knowledge and practice were observed in 58% and 78.9% of the respondents, respectively. The mean knowledge and practice scores were 0.5827 ± 0.25021 and 0.7899 ± 0.21828 , respectively. There was a moderate positive correlation between the mean knowledge and practice scores ($r=0.684$, $p<0.001$). No statistically significant differences between the average ranks of knowledge and practice when comparing the different categories of sociodemographic characteristics ($p>0.05$).

Table 2 – Nurses' knowledge of computed tomography scan safety (n=131). Saudi Arabia, 2021

Items	Yes	No	I do not know
	n (%)	n (%)	n (%)
Do you have previous experience of CT procedures?	80 (61.1)	50 (38.2)	1 (0.8)
Have you been trained in patient preparation for CT?	100 (76.3)	31 (23.7)	0 (0.0)
Do you know what "CT" stands for?	114 (87.0)	9 (6.9)	8 (6.1)
Is informed consent required before a CT scan procedure?	107 (81.7)	19 (14.5)	5 (3.8)
Have you attended any courses on CT scan safety procedures?	22 (16.8)	108 (82.4)	1 (0.8)
Have you ever visited a CT scan room?	122 (93.1)	6 (4.6)	3 (2.3)
Are you aware of patient preparation before a CT scan?	97 (74.0)	25 (19.1)	9 (6.9)
Do you know the type of radiation used in CT?	43 (32.8)	77 (58.8)	11 (8.4)
Do you know the hazards of ionizing radiation?	59 (45.0)	57 (43.5)	15 (11.5)
Do you know categories of patients for whom CT poses a high risk?	64 (48.9)	57 (43.5)	10 (7.6)
Should patients fast prior to CT procedures?	61 (46.6)	49 (37.4)	21 (16.0)
Do you know medical conditions that are contraindicated for contrast agents?	81 (61.8)	39 (29.8)	11 (8.4)
Do you know why patients undergoing CT scans with contrast agents need to be checked for creatinine levels (glomerular filtration rates)?	79 (60.3)	36 (27.5)	16 (12.2)
Are you aware of adverse reactions to contrast agents?	62 (47.3)	50 (38.2)	19 (14.5)
Do you know how to manage a patient having an adverse reaction to a contrast agent?	54 (41.2)	59 (45.0)	18 (13.7)

CT: computed tomography

Table 3 – Nurses' practice toward computed tomography scan safety (n=131). Saudi Arabia, 2021

Items	Correct	Incorrect	I do not know
	n (%)	n (%)	n (%)
Explain the procedure to the patient and his/her family	125 (95.4)	3 (2.3)	3 (2.3)
Obtain properly signed informed consent	114 (87.0)	7 (5.3)	10 (7.6)
Assess any history of allergies to iodinated dyes if a contrast medium is to be used	114 (87.0)	6 (4.6)	11 (8.4)
Ask the patient about any medical conditions and currently used medications	113 (86.3)	9 (6.9)	9 (6.9)
Instruct the patient not to eat or drink for 12 hours if a contrast agent is to be used	80 (61.1)	21 (16.0)	30 (22.9)
Instruct the patient to wear comfortable, loose-fitting clothing (gown) during the procedure	107 (81.7)	9 (6.9)	15 (11.5)
Warn the patient of mild pain from the needle puncture and a flushing sensation from a contrast agent injection or a metallic taste from an oral contrast agent	90 (68.7)	9 (6.9)	32 (24.4)
Inform the patient that the procedure takes a maximum of 30 minutes, depending on the type of computed tomography scan and the patient's ability to relax and remain still	95 (72.5)	10 (7.6)	26 (19.8)
Instruct the patient to remove any metallic objects, such as earrings and bobby pins	119 (90.8)	8 (6.1)	4 (3.1)
Mention the expected flushing sensation if a contrast dye is administered intravenously	98 (74.8)	8 (6.1)	25 (19.1)
Instruct the patient to avoid moving during the scan	119 (90.8)	3 (2.3)	9 (6.9)
The patient lies on an adjustable table inside an encircling body scanner; straps and pillows may be used to help maintain the correct position	114 (87.0)	3 (2.3)	14 (10.7)
The patient may be instructed to hold his/her breath during the scan.	57 (43.5)	28 (21.4)	46 (35.1)
Carefully assess the patient for adverse effects of the contrast medium	110 (84.0)	5 (3.8)	16 (12.2)
Encourage the patient to increase fluid intake (if a contrast agent is administered)	97 (74.0)	5 (3.8)	29 (22.1)
Before allowing the patient to leave the computed tomography department, ensure that he/she is conscious and alert and his/her vital signs are stable	118 (90.1)	2 (1.5)	11 (8.4)
Inform the patient that he/she can resume activities after the procedure	89 (67.9)	8 (6.1)	34 (26.0)

Discussion

Patients undergoing computed tomography are at risk of various hazards, including ionizing radiation exposure, adverse reactions to contrast agents, and infections. Qualified nurses with adequate knowledge and training may minimize these risks. This study evaluated nurses' knowledge of and practice toward computed tomography safety protocols and the extent to which they follow the recommended practices. It is the first study to evaluate nurses' knowledge, and practices related to computed tomography safety protocols in Saudi Arabia. The findings suggest insufficient knowledge but adequate practice levels. Majority of participants had visited a computed tomography scan room, and more than half of them had experience of computed tomography procedures. Researchers also found that most of the participating nurses had experience with a computed tomography scanner⁽¹²⁾. This high percentage highlights the importance of providing nurses with knowledge and training to minimize potential hazards.

Although majority of nurses reported explaining the imaging procedure to the patients and their families, only few of them knew the type of radiation used in computed tomography, and only around half of nurses were aware of the hazards of ionizing radiation. This indicates poor knowledge of the radiation risks, which may result in providing patients with incorrect information or insufficient risk management. Insufficient knowledge of radiation safety protocols has been reported previously⁽¹¹⁾. Moreover, a previous study showed that, although nurses were aware of the risk of radiation, they had difficulty estimating the exact dose equivalent to a chest X-ray dose in various computed tomography procedures⁽¹³⁾.

Even though large number of our respondents asked patients about any current medical conditions, more than half of them did not know what categories of patients are at high risk during computed tomography. More than a third of nurses did not know the conditions that are contraindicated for contrast me-

dia, indicating relatively poor knowledge of patients who should avoid computed tomography, which may increase the risk of computed tomography adverse events.

Surprisingly, around half of our respondents did not know why creatinine levels must be checked before administering contrast agents. When a contrast medium is injected, there is a risk of adverse reactions, ranging from mild, such as nausea and vomiting, to severe, such as cardiopulmonary arrest, laryngospasm, or contrast-induced nephropathy, which usually occurs during the first 24–72 hours^(14–16). Therefore, it is essential to carefully assess patients, especially those with known renal dysfunction, before injecting contrast media by measuring their creatinine levels to avoid possible complications⁽¹⁷⁾.

Majority of the participants reported carefully assessing patients for adverse reactions to contrast agents. However, more than half of nurses were not aware of adverse reactions to contrast media, and more than half of nurses did not know how to manage their patients, which may pose significant risks for patients in the event of adverse reactions. A recent study found that nurses were aware that the safety of elderly patients undergoing cardiac computed tomography with contrast agents was contingent on accurately assessing adverse reactions related to radiopharmaceutical⁽¹⁰⁾.

Another important finding of our study is that only a few respondents attended courses on computed tomography safety procedures, which may explain their poor knowledge of or misconceptions about safety guidelines. It has been shown that educational programs improve nurses' knowledge and practices related to reporting adverse reactions to drugs⁽¹⁸⁾. Radiation education is necessary, particularly for nurses working outside radiology departments, to foster a culture of radiation awareness and safety⁽¹⁹⁾.

A positive correlation between nurses' education level and completion of medical radiation education and their knowledge of radiation physics and principles of radiation use has been reported^(10–11).

Furthermore, it has been shown that formal training in radiation safety outside work is positively associated with knowledge of radiation safety⁽¹²⁾. Nevertheless, there is currently no formal education for nurses regarding different radiological procedures and patient preparation in the health centers of our study. We suggest that educational programs and training can improve nurses' CT-related practices and reduce adverse events.

Study limitations

Regarding the limitation of this single city, the results of our study cannot be generalized. Furthermore, due to time constrain sample size did not reach the expected leading to small and un-representative sample size. Finally, the respondents' academic curricula before working at the hospitals were not considered. Nurses graduating from different universities may have different levels of knowledge and practice correctness. Based on this study's findings, the following recommendations can be made. For nursing staff, we recommend regular workshops, seminars, and symposia on computed tomography scan safety preparations. For researchers, we strongly recommend continuing this line of research and conducting studies in different regions to evaluate the impact of educational courses in enhancing nurses' knowledge and practice.

Contributions to practice

The findings of this study inform that knowledge is essential for guiding nursing practice toward appropriate safety of patient undergoing computed tomography scan.

Conclusion

Although nurses showed a satisfactory level of practice, nurses' knowledge about safety protocols was inadequate. In several circumstances, this was

accompanied by insufficient knowledge. Educational programs about radiology safety protocols are essential to build a well-informed nurse.

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Authors' contributions

Conception and design, methods, data analysis, and drafting the manuscript or revising it critically for important intellectual content: Algamdi M, Alghamdi A. Conception, methods, and interpretation of data: Dauod K.

Conception and drafting the manuscript: Alatawi K. Conception, data collection, and drafting the manuscript: Alrawaili M, Alhwiti M, Albalawi A.

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Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Algamdi M, Alghamdi A.

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