Original Article

Necessity of Obtaining a Delayed Bladder Phase Scan in Follow-up CT Whole Abdomen of Non-urinary Tract Cancer Patients

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Abstract

Introduction/ Objectives: To explore the necessity of obtaining a delayed bladder phase CT scan in follow-up CT whole abdomen of non-urinary tract cancer patients.

Methods: The follow-up routine contrast-enhanced CT whole abdomen protocol of 505 non-urinary tract cancer patients, who had no urinary tract symptoms, were retrospectively reviewed. The CT findings of the pelvic cavity between interpretation with and without the delayed bladder phase scan were analyzed by McNemar's test.

Results: Of the 505 patients, 241 (47.7%) were men and 264 (52.3%) were women, with a mean age of 64 years old. There was no statistically significant differences in interpretation of the CT findings between those with and without the delayed bladder phase scan (P = .063, 95% CI 0.962 - 0.997).

Conclusion: The delayed bladder phase scan had no significant yield in follow-up CT whole abdomen of non-urinary tract cancer patients who had no urinary tract symptoms.

Keywords: Delayed bladder phase, CT, Abdomen

Volume 2023, Issue 1, Page 42-50

https://asianmedjam.com/

Received: 28 February 2022 **Revised: 2 September 2022** **Accepted: 19 September 2022**

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Introduction

Computed tomography (CT) has become a widely used imaging tool for the diagnosis, staging, treatment planning, and follow-up of cancer patients; however, it carries a potential risk of radiation-induced malignancy, which is an increasing concern. Although the exact risk of malignancy from CT remains uncertain,[1] CT must be performed based on the ALARA (as low as reasonably achievable) principle of radiation protection. Currently, there are many techniques to reduce the CT radiation dose, including, but not limited to, automated exposure control, modifying the acquisition parameters and CT protocols (decreasing the number of scan phases, increasing the section thickness, and adjusting the peak voltage (kVp), tube-current time product, and pitch), and iterative reconstruction.[2] Some studies found that a large proportion of patients who underwent abdominal/pelvic CT scans received unnecessary additional scan phases that added a substantial excess radiation dose.[3,4] Thus, multiphase CT studies should be performed only in certain indications in order to improve the detection and characterization of lesions.

The routine CT whole abdomen (abdomino-pelvic) protocol varies among institutions. In our institution, the routine protocol for contrast-enhanced CT whole abdomen includes the non-contrast and portovenous phase, covering the whole abdomen, and the delayed bladder phase at 10 minutes after intravenous contrast injection, covering the pelvis, with the additional arterial phase of the upper abdomen used as an optional phase in some indications. In cancer patients who will undergo multiple CT examinations over their lifetime, a reduction of unnecessary CT scan phases along with the use of other techniques to reduce the radiation dose but still maintain an adequate diagnostic imaging quality and information are crucial. Recently, virtual non-contrast images from dual energy CT have emerged with the potential to replace the non-contrast phase scan. To the best of our knowledge, however, the necessity of including the delayed bladder phase in the routine CT whole abdomen protocol has not yet been addressed.

The purpose of the present study was to evaluate the necessity of the delayed bladder phase scan in follow-up CT whole abdomen of non-urinary tract cancer patients. The authors did not evaluate urinary tract cancer patients, because these patients usually undergo a more specific CT protocol, i.e., CT urography.

Methods

Study Population

This retrospective, cross-sectional, single-center study was approved by the institutional review board (COA no. Si 1062/2020). The requirement to obtain written informed consent was waived. From January 2020 to December 2020, 605 consecutive adult (age > 18 years old) non-urinary tract cancer patients who underwent follow-up contrast-enhanced CT whole abdomen in our institution were selected for consideration in the study. The exclusion criteria were the following: a) patients with known urinary tract involvement or who had any clinical symptom that indicated a suspected urinary tract abnormality, b) patients with a history of trauma, c) no delayed bladder phase images available, or d) no available prior CT examination. If multiple CT examinations were done during the studied period, only the latest examination was selected in the study. Ultimately, 505 CT examinations were included in the study. Review of the patients' electronic charts, including the patients' demographics and clinical data, was done by a 3rd year diagnostic radiology resident who was not involved in the imaging interpretation.

Acquisition Protocol

CT examinations were performed with 64 or 256 detectors helical CT scanners (Discovery CT 750HD, Revolution CT, Revolution APEX CT; GE Healthcare, United States). CT whole abdomen was routinely performed during a breath hold, including the non-contrast phase, portovenous phase (delayed 80 seconds after contrast administration), and delayed bladder phase (delayed 10 minutes after contrast administration). The non-contrast and venous phase of the whole abdomen scan covered the hepatic dome to the pubic symphysis. The scan coverage of the delayed bladder phase was performed from the iliac crest to the pubic symphysis. Approximately 2 mL/kg of nonionic iodinated contrast agent was injected, followed by 20 mL of normal saline solution (NSS), using a power injector at a rate of 3 mL/second.

The CT technical parameters included: voltage, 120 kVp; variable tube current, 300 - 400 mA, depending on the size of the patient; pitch ratio, 1.375:1; rotation time, 0.5 second; section thickness, 1.25 mm; and reconstruction interval, 5 mm.

Imaging Interpretation and Analysis

The selected CT examinations were retrospectively reviewed with the consensus opinion of two radiologists who have more than 10-years' experience in abdominal CT, two times separately (2 months apart). At the first time, the non-contrast and portovenous phase images were reviewed. Then two months later, the non-contrast, portovenous, and delayed bladder phases images were reviewed. The two reviewers were blinded to the patients' clinical history, official CT reports, and findings at the previous imaging examinations.

CT interpretation of any abnormalities in the pelvis were done, including bladder and distal ureter, uterus, ovary and adnexa, prostate gland and seminal vesicles, visualized bowel, visualized vessels, and other findings. The study did not include some findings, such as bone lesions, atherosclerosis, or enlarged prostate gland. The clinical relevance of the abnormal CT findings detected by the consensus opinion of two reviewers was assessed considering the patient's clinical data, prior CT findings, and follow-up CT if available, by a 3rd year diagnostic radiology resident.

The CT findings were analyzed to assess whether the delayed bladder images changed the significant diagnosis from the non-contrast and portovenous phases, by McNemar's test, considering results with $P < .05$ as being statistically significant. The patients' demographics and clinical data were reported by descriptive analysis. SPSS version 23 software was used for the statistical analysis in this study.

Results

Table 1 shows the demographics data and underlying malignancy of the study population. Of the 505 patients included in the study, 241 (47.7%) were men and 264 (52.3%) were women, with a mean age of 64 years old (range 22-94 years old). The most common underlying cancer in this study was GI tract malignancy (56.4%), and colorectal cancer was the most common GI tract cancer in this study.

The correlation of the CT findings between the two imaging groups (with and without delayed bladder phase) is shown in Table 2. There was no statistically significant differences in CT findings between the two imaging groups (P = .063, 95% CI 0.962 - 0.997). The delayed bladder phase rarely added further findings from the non-contrast and portovenous phases.

In the present study, there were only nine discordances between the CT findings for the two imaging groups (Table 3). The delayed bladder phase scan better helped identify four cases of double collecting system than the portovenous phase, in which one case also had a simple ureterocele. Figure 1 showed double collecting system of right ureter with a simple ureterocele. Delayed bladder phase CT image (Figure 1B) identified double collecting system of right ureter which not well visualized on the portovenous phase CT image (Figure 1A). Figure 1C shown contrast opacification of a simple right ureterocele on the delayed bladder phase CT image. Non-opacification of the bilateral external iliac and common femoral veins seen on the portovenous phase in three cases were confirmed to be pseudothrombosis of these vessels on the delayed bladder phase scan. Figure 2 showed pseudothrombosis of bilateral external iliac veins. Non-opacification of bilateral external iliac veins on the portovenous phase CT image (Figure 2A) was seen as a homogenous enhancement on the delayed bladder phase CT image (Figure 2B), confirming pseudothrombosis. The delayed bladder phase demonstrated a contrast-filled vagina in one case, without clinical or imaging evidence of fistula between the vagina and urinary tract. This could be related to the passing of contrast-opacified urine into the vagina through the introitus. Figure 3 showed a case of a small filling defect in the urinary bladder identified on the delayed bladder phase CT image (Figure 3B) without an abnormality seen on the portovenous phase CT image (Figure 3A). However, a retrospective review found that there were no clinical symptoms and no demonstrable filling defect in the urinary bladder on the prior CT study and follow-up CT study. The authors, thus, assumed that it was a pseudo-filling defect in the urinary bladder, maybe from unopacified urine.

Table 1 Study population demographics and underlying cancers

Characteristics	Value
Age (years)	
Range	22 - 94
Mean	64
Median	65
Gender: number (%)	
Male	241 (47.7%)
Female	264 (52.3%)
Underlying cancers[a]: number (%)	
GI tract *(rectum n = 146, colon n = 115, stomach n = 14, anus n = 5, esophagus n = 4, appendix n = 1)*	285 (56.4%)
Lung	92 (18.2%)
Breast	45 (8.9%)
Female genital organs *(endometrium, n = 12; ovary, n = 9; cervix, n = 6; fallopian tube, n = 2)*	29 (5.7%)
Hematologic malignancy *(lymphoma, n = 14; leukemia, n = 2)*	16 (3.2%)
Pancreas	15 (3%)
Male genital organs *(prostate, n = 11; testis, n = 2; penis, n = 1)*	14 (2.8%)
Head and neck	7 (1.4%)
Hepatobiliary system *(HCC, n = 1; gallbladder, n = 4; cholangiocarcinoma, n = 2)*	7 (1.4%)
Others *(musculoskeletal, n = 4; melanoma, n = 3; periampullary, n = 2; adrenal, n = 2; schwannoma, n = 1)*	12 (2.4%)

[a]17 cases had underlying cancers involving two organs

Table 2 Correlation of the CT findings between the two imaging groups (with and without delayed bladder phases)

CT findings	NC+PV phases number (%)	NC+PV+DB phases number (%)	*P*-value	95%CI
Overall findings[a]			.063	0.962 - 0.997
- Normal	284 (56.2%)	279 (55.2%)		
- Abnormal	221 (43.8%)	226 (44.8%)		
Bladder and distal ureter			.063	0.922 - 0.945
- Normal	438 (86.7%)	433 (85.7%)		
- Abnormal	67 (13.3%)	72 (14.3%)		
Uterus			1.0	0.968 - 1.0
- Normal	454 (89.9%)	453 (89.7%)		
- Abnormal	51 (10.1%)	52 (10.3%)		
Ovary and adnexa			1.0	1.0 - 1.0
- Normal	490 (97%)	490 (97%)		
- Abnormal	15 (3%)	15 (3%)		
Prostate and seminal vesicles			1.0	1.0 - 1.0
- Normal	502 (99.4%)	502 (99.4%)		
- Abnormal	3 (0.6%)	3 (0.6%)		
Visualized bowel			1.0	1.0 - 1.0
- Normal	448 (88.7%)	448 (88.7%)		
- Abnormal	57 (11.3%)	57 (11.3%)		
Visualized vessels			.25	0.573 - 1.0
- Normal	499 (98.8%)	496 (98.2%)		
- Abnormal	6 (1.2%)	9 (1.8%)		
Other findings			1.0	1.0 - 1.0
- Normal	414 (82%)	414 (82%)		
- Abnormal	91 (18%)	91 (18%)		

[a]55 cases have more than one abnormality.
Abbreviations: NC = noncontrast, PV = portovenous, DB = delayed bladder.

Table 3 Discordance of the CT findings between the two imaging groups (with and without delayed bladder phases)

CT findings	NC+PV phases	NC+PV+DB phases
Bladder and distal ureter		
- Double collecting system[a]	0	4
- Filling defect in bladder	0	1
Visualized vessels		
- Non-opacification of bilateral external iliac and common femoral veins	3	0
Uterus		
- Contrast filled in vagina	0	1

[a]One case of a double collecting system had simple ureterocele.
Abbreviation: NC = noncontrast, PV = portovenous, DB = delayed bladder.

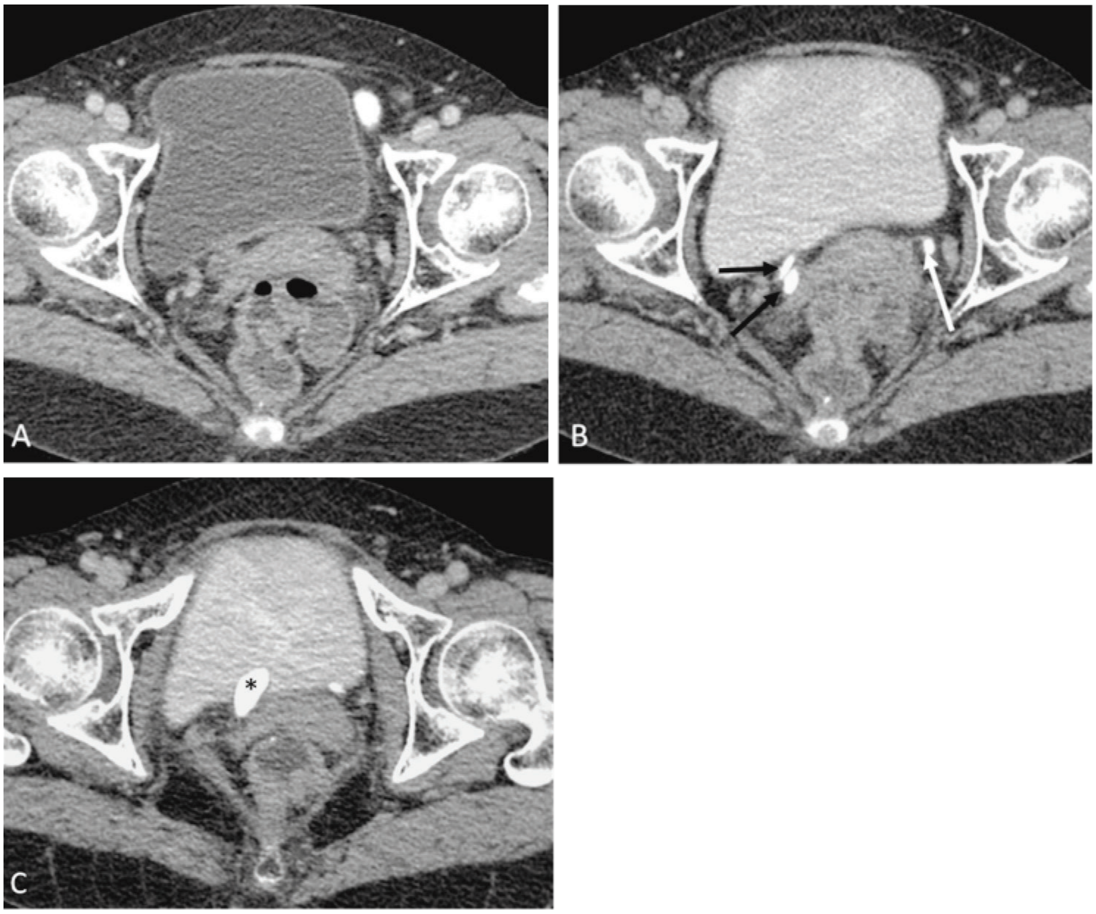

Figure 1 shown double collecting system of right ureter (black arrow) with a simple ureterocele (asterisk). There was normal left distal ureter (white arrow).

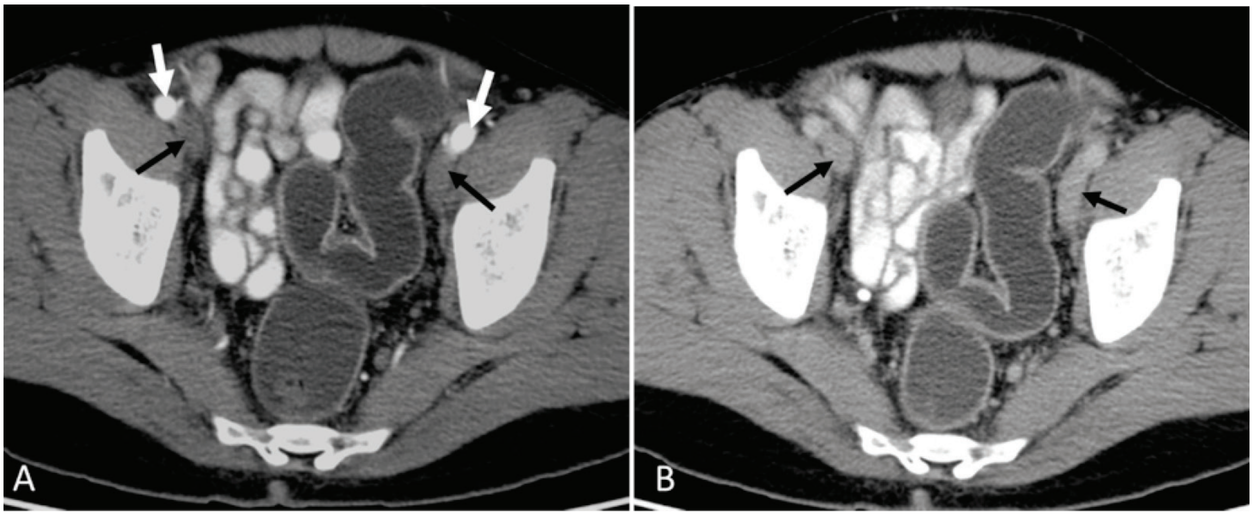

Figure 2 showed pseudothrombosis of bilateral external iliac veins (black arrow). Noted marked enhancement of the bilateral external iliac arteries (white arrow) from an improper venous phase due to a poor cardiac output.

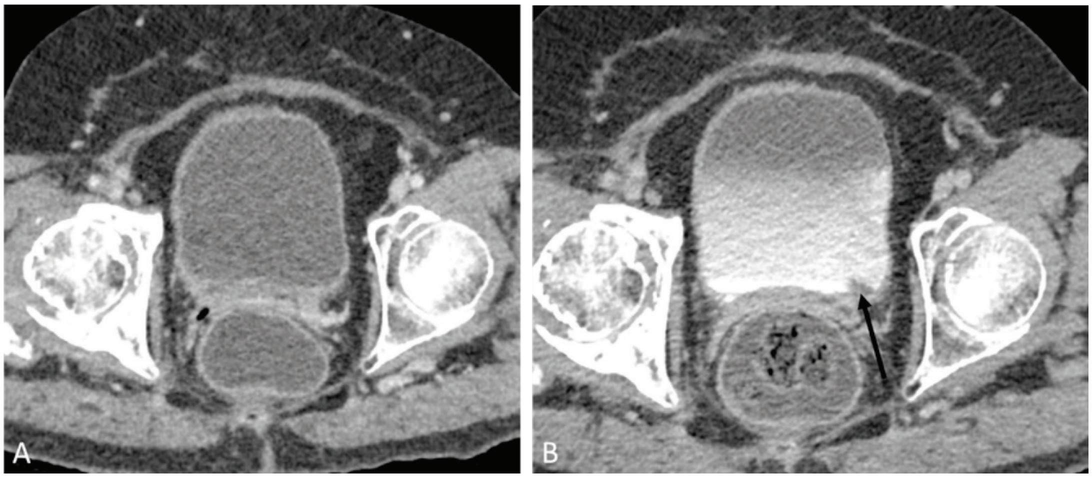

Figure 3 showed small filling defect (black arrow) in urinary bladder on the delayed bladder phase without an abnormal lesion on the portovenous phase, could be pseudo-filling defect from non-opacified urine.

Discussion

While CT is widely used, radiation associated with CT is becoming of great concern, especially in patients who undergo multiple CT examinations, e.g., cancer patients. There are many techniques to reduce the CT radiation dose. Among these techniques, one important and easy way to decrease the CT radiation dose without a drop in diagnostic imaging quality is by the elimination of unnecessary CT scan phases. A study by Guite et al.[3] suggested that a large proportion of patients who undergo abdominal/pelvic CT examination receive medically unnecessary multiphase scans.

There are some prior studies about the potential benefits of the delayed scan in abdominal/pelvic CT examinations, such as trauma; evaluation of a renal, adrenal, hepatic, or pancreatic mass; and assessment of endoleaks in patients who have undergone endovascular aortic aneurysm repair.[5-12] However, the necessity of the delayed bladder phase in the routine CT whole abdomen protocol has not yet been addressed. The delayed bladder phase in routine CT whole abdomen examination may help in the evaluation of intravenous contrast excretion into the urinary tract and aid better identification of the urinary bladder and both distal ureters. It may also help distinguish between the opacified urinary tract and adjacent cystic structure, or provide more information of the urinary tract involvement from adjacent tumors. Delayed images will increase the conspicuity and may help in the diagnosis of filling defects in the urinary tract, which could be related to a neoplasm, blood clot, or fungus.[13] In addition, a delayed phase image may identify or confirm a leakage of contrast material from the urinary tract or vascular system.[13]

The present study found that obtaining a delayed bladder phase scan had no significant yield in the follow-up of non-urinary tract cancer patients who had no urinary tract symptoms or urinary tract involvement. However, delayed bladder phase identified a double collecting system in 4 of 505 cases in the present study and demonstrated 1 case of contrast-filled vagina, which could not be well seen on the portovenous phase, and helped confirmation of pseudothrombosis of the bilateral external iliac and common femoral veins in 3 of 505 cases. However, most of these findings were already shown on prior CT study. Therefore, the delayed bladder phase did not add benefit over routine CT whole abdomen for the follow-up cases in this study. A study by Chan et al.[4] evaluated the delayed phase scan from the hepatic dome to the bottom of the kidneys at 3 minutes after intravenous contrast injection and suggested that it had no clear benefit other than for assessment of the excretion of the renal contrast material in routine abdominal/pelvic CT. However, there was a difference in the routine CT protocol used in that study compared to in our study.

Our findings suggest that abandoning the delayed bladder phase as part of routine CT whole abdomen in the follow-up of non-urinary tract cancer patients who do not have known indications to the required delayed phase will reduce the radiation exposure of patients, the interpretation time, the examination time, and decrease the data storage resources needed.

The present study has some limitations to note. First, the present study had selective bias in the study population, which does not reflect the overall general population. Here, the selection of non-urinary tract cancer patients who had no urinary tract involvement and did not have any symptom that indicate suspected urinary tract abnormality meant they were also unlikely to have any suspicious findings about the urinary system. However, the present study was aimed at this population group in order to evaluate whether the delayed bladder phase can be discarded if the cancer patients have no suspicious clinical indications of urinary tract disease. Second, the CT findings were retrospectively reviewed by the consensus opinion of two radiologists and previous reports were not used in the interpretation, in which some findings might have already shown up on the prior CT studies. In addition, both reviewers knew the study aims and might have had some potential bias in their CT interpretation of the preferred CT phase images. The CT interpretations with and without the delayed bladder phase were separately performed two times at 2 months apart in order to reduce recognition bias. Finally, the radiation dose was not studied in the present study.

The present study suggests that the delayed bladder phase had no significant benefit in follow-up CT whole abdomen of non-urinary tract cancer patients who had no urinary tract symptoms or urinary tract involvement. Omitting the delayed bladder phase in those patients would substantially reduce the excess radiation dose, interpretation time, scan time, and inefficient use of resources.

Acknowledgements

The authors gratefully acknowledge Ms. Nerisa Thornsri, M.Sc. (Applied Statistics), Clinical Epidemiology Division, Research and Development Department, Faculty of Medicine Siriraj Hospital, Mahidol University, for assistance with the statistical analysis.

Conflicts of Interest Declaration The authors declare they have no personal or professional conflicts of interest, and receive no financial support from the companies that produce and/or distribute the drugs, devices, or materials described in this report.

Funding Disclosure AC and SP were supported by a Chalermphrakiat Grant from the Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand.

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