

Original Research Paper

## Image quality comparison of abdominal MSCT: Injector vs. Syringe Method

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### Abstract

Contrast-enhanced abdominal multislice computed tomography examinations can be performed using intravenous contrast media via automatic injectors or manual syringes. This study aims to compare image quality in the arterial and delayed phases of abdominal multislice computed tomography using these two methods and to analyze cost differences. A quantitative experimental design was applied, involving six patients divided into two groups: three examined using an automatic injector and three using a manual syringe. Inclusion criteria included patients with abdominal tumors, while those with contrast allergies or elevated creatinine levels were excluded. Image quality was assessed using Hounsfield Unit (HU) measurements and Visual Grading Analysis. Data were statistically analyzed using SPSS version 24. The automatic injector administered contrast at a flow rate of 3.5 mL/s followed by 40 mL saline, with arterial phase imaging at 25 seconds post-injection and delayed phase at 5 minutes. The manual method involved no saline, with arterial phase imaging immediately post-injection and delayed phase at 10 minutes. The Wilcoxon test was used for within-group comparisons, and the Mann-Whitney U test for between-group comparisons. Results showed a significant difference in arterial phase image quality, favoring the automatic injector, while no significant difference was found in the delayed phase between methods. The injector method provided superior arterial phase images, whereas both methods yielded comparable image quality in the delayed phase. Thus, for delayed phase imaging, the syringe method is a cost-effective alternative without compromising diagnostic quality.

**Keywords:** abdominal tumor; arterial phase; delay phase; image quality; MSCT Abdomen Contrast

### 1. Introduction

The abdominal cavity is the space within the human body that extends from the diaphragm to the upper border of the pelvic bones. It contains vital organs such as the liver, stomach, bile ducts, gall bladder, small intestine, large intestine, kidneys, pancreas, and spleen. Each organ in the abdominal cavity receives its blood supply from the abdominal aorta (Flynn & Vickerton, 2025). One of the most common abnormalities in the abdominal and pelvic cavities is the presence of abdominal tumors. (X.-M. Li et al., 2014).

A tumor or abdominal mass is a solid tissue growth that originates from the transformation of body cells that grow autonomously, regardless of normal growth regulation (Koshi, 2025). Tumors can be benign, malignant, or precancerous. Intra-abdominal tumors can occur in any organ, including the liver, kidneys, cervix, rectum, colon, and others (Afriani, 2024). The development of this tumor can cause local effects such as obstruction of the ureter or inferior vena cava, as well as forming fibrotic tissue that wraps around the surrounding structures without invading (Trigui et al., 2023).

In radiology, intra-abdominal tumor detection relies heavily on imaging technologies such as computed tomography (CT) scans. With technological advancements, the use of multi-slice computed tomography (MSCT) allows for faster examinations and more detailed imaging results. Contrast-

enhanced abdominal MSCT can be performed by administering contrast media intravenously (S. Li et al., 2023)

The MSCT Abdomen contrast examination begins with patient preparation with allergy screening and kidney function tests, then using contrast media administered orally and IV (Francis et al., 2003). Intravascular contrast media administration using an injector with water-soluble iodine with a volume of 100-120 ml, flow rate of 2.5 ml/s, delay of 70 seconds (Seeram, 2016)

The MSCT Abdomen contrast examination technique uses IV contrast media via an injector with a multiphase technique consisting of the late arterial phase, venous phase, and delay phase (Melikian et al., 2016). The arterial phase evaluates arterial anatomy and is the initial phase that occurs after a delay of approximately 15-40 seconds (Endrikat et al., 2018). Corticomedullary or venous phase evaluates venous phase anatomy and reveal enhancement in the renal cortex, starting approximately 30-40 seconds after contrast media injection (Irfan Irfan & Rahmat Widodo, 2024). The delay phase is used to optimize visualization of certain organs and tissues, especially in detecting and evaluating abnormalities in the liver, blood vessels, and urinary tract, starting approximately 300 seconds post-injection (Wijokongko et al., 2017).

The contrast-enhanced abdominal MSCT examination at the Radiology Unit of PKU Muhammadiyah Gamping Hospital is performed using two contrast media injection techniques intravenously: using an automatic injector and manually using a syringe. The contrast media used for both methods is non-ionic, with a volume of 50 mL and a contrast concentration of 350 mg I/mL. (Paparo et al., 2014). For the injector method, contrast media is administered at a flow rate of 3.5 mL/s followed by 40 mL of saline. The arterial phase is acquired 25 seconds after contrast injection, and the delayed phase is acquired 5 minutes afterward. In contrast, the manual injection method is performed without saline; the arterial phase is taken immediately after the manual injection is completed, and the delayed phase is acquired 10 minutes after contrast media administration (McDermott et al., 2020). However, there has been no research that specifically compares the image quality of the two methods, namely the use of injectors and syringes in the artery phase and delay phase, especially in terms of detail, contrast, and image sharpness (Choi et al., 2022).

Based on the researchers, this study was conducted to evaluate the differences in image quality between two contrast media administration methods and to analyze the cost implications of using injectors versus syringes. This study has novelty in terms of comparing the quality of abdominal MSCT images between the use of injectors and syringes directly, which has not been widely studied before, especially in this hospital. This study is expected to provide a basis for determining the best method to improve image quality in contrast-enhanced abdominal MSCT examinations.

## 2. Research Methods

This quantitative study applied an experimental approach to determine the differences in abdominal MSCT image quality between the arterial and delayed phases using two contrast media delivery methods: a automatic injector and a manual syringe, in patients with abdominal tumors. Inclusion criteria included patients with abdominal tumors, while exclusion criteria included patients with allergies to contrast media and high creatinine. The study was conducted from March to May 2025 at the Radiology Department of PKU Muhammadiyah Gamping Hospital, using a Canon 160-slice CT scanner. Ethics approval was granted under No. 037/KEP-PKU//2025 from PKU Muhammadiyah Gamping Hospital.

Each study sample was divided into two groups: three patients were examined by using the automatic injector, and three patients were examined by using the manual syringe for abdominal MSCT scans. Image analysis results were analyzed in Hounsfield Unit (HU) and Visual Grading Analysis. In obtaining the HU value that can only be used in the artery phase, a Region Of Interest (ROI) with a

diameter of 5 mm is created, then placed in the area of the object being assessed, namely the anatomy of the descending aorta. In obtaining Visual Grading Analysis for the artery phase with the assessed indicators, visualization of arterial blood vessels and contrast enhancement is visible, while for the delay phase with the assessed indicators, differentiation of blood vessels with surrounding tissue is visible, and can reveal the presence or absence of pathological abnormalities. Image quality was evaluated by a radiologist using a scoring system based on specific criteria for both the arterial and delayed phases. In this assessment, a score of 3 (Good) was given when, in the arterial phase, arterial blood vessels and contrast enhancement were clearly visible, and in the delayed phase, there was clear differentiation between blood vessels and surrounding tissue, allowing for accurate identification of pathological abnormalities. A score of 2 (Sufficient) was assigned when, in the arterial phase, contrast enhancement was visible but less optimal, and in the delayed phase, pathological abnormalities could be identified although the tissue differentiation was not clearly defined. A score of 1 (Poor) was given when, in both the arterial and delayed phases, the expected anatomical and pathological indicators—such as vascular visibility, contrast enhancement, and tissue differentiation—were not clearly visualized. The total image quality score ranged from 3 to 9, and was categorized as follows: 8–9 = Good, 6–7 = Sufficient, and 3–5 = Poor.

After all the images were obtained, they were then analyzed digitally using SPSS version 24 software for statistical processing.

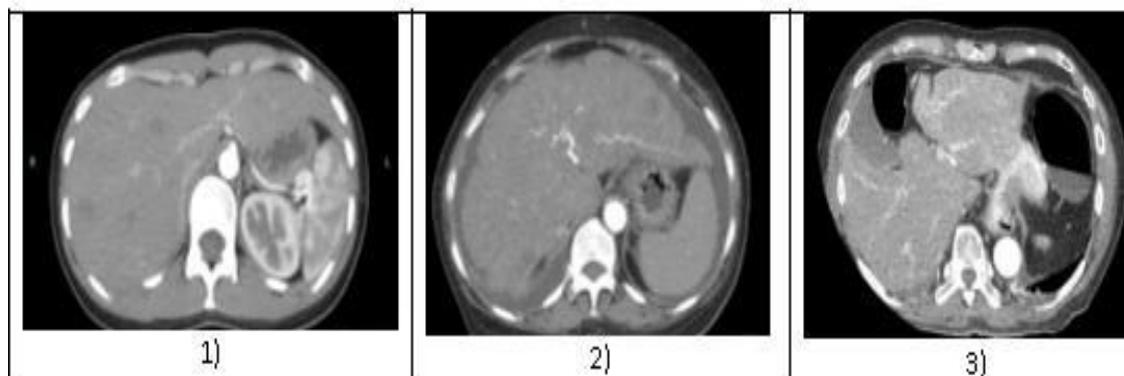
### 3. Results and Discussion

#### 3.1. Results

The contrast media used for the 2 methods were non-ionic, with a volume of 50 mL and a contrast concentration of 350 mg I/mL. The use of an injector with a flow rate of 3.5 mL/s, 40 mL saline, the arterial phase was taken 25 seconds post-contrast, and the delay phase was 5 minutes post-contrast, while in the manual injection method, contrast media was administered without the use of saline. The arterial phase image was acquired immediately after the completion of the manual injection, while the delayed phase image was taken 10 minutes after the contrast media administration. The image quality of abdominal contrast-enhanced MSCT in the arterial and delayed phases was evaluated for both the injector and syringe groups.

#### 3.1.1. Contrast Abdominal MSCT Image Results

##### 3.1.1.1. Arterial phase assessment results with injector



**Figure 1. Arterial Injector Phase**

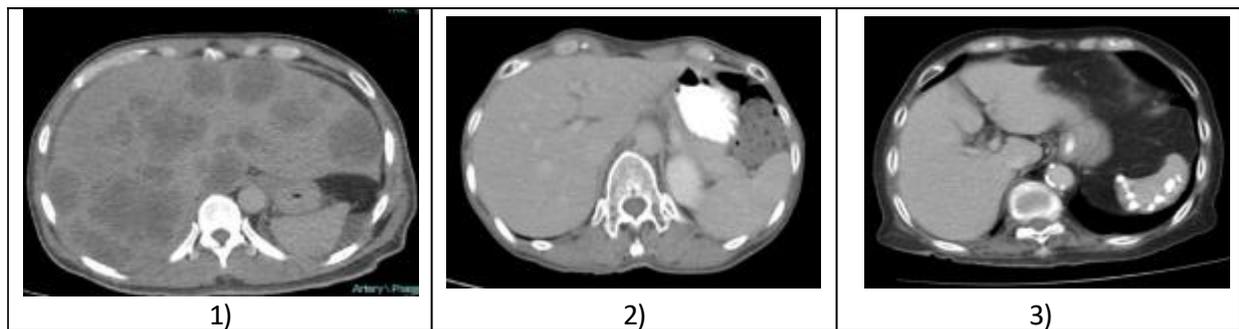
Based on the results of the assessment by the radiology specialist regarding Figure 1, it can be seen in Table 1 based on visual grading analysis of aspects of detail, contrast, and sharpness.

**Table 1.** Results of image assessment based on visual grading analysis

No	Patient Code	Contrast Method	Anatomical Detail	Contrast	Sharpness	HU	Total Score
1	P01	Injector	3	3	3	350	9
2	P02	Injector	3	3	3	370	9
3	P03	Injector	3	3	3	365	9

Based on visual grading analysis, the three arterial phase images obtained using an injector were consistently rated as 'good' by radiologists, achieving a total score of 9 for detail, contrast, and overall image quality.

### 3.1.1.2. Arterial Phase Assessment Results using a Syringe

**Figure 2.** Arterial Syringe Phase

Based on the results of the assessment by a radiology specialist regarding Figure 2 can be seen on Table 2

**Table 2.** Based on Visual Grading Analysis of aspects of Detail, Contrast, and Sharpness.

No	Patient Code	Contrast Method	Anatomical Detail	Contrast	Sharpness	HU	Total Score
1	P01	Sputit	1	1	1	35	3
2	P02	Sputit	1	1	1	40	3
3	P03	Sputit	1	1	1	37	3

The data showed that, based on the visual grading analysis conducted by a radiology specialist on three arterial phase images obtained using a manual syringe, the images were rated poorly in terms of anatomical detail and contrast, with total scores of less than 3 across all evaluated aspects.

### 3.1.1.3. Results of The Delay Phase Assessment with The Injector

**Figure 3.** Injector Delay Phase

Based on the results of the assessment by a radiology specialist regarding Figure 3 can be seen on Table 3

**Table 3.** Based on Visual Grading Analysis of Aspects of Detail, Contrast, and Sharpness

No	Patient Code	Contrast Method	Anatomical Detail	Contrast	Sharpness	Total Score
1	P01	Injector	3	3	3	9
2	P02	Injector	3	3	3	9
3	P03	Injector	3	3	3	9

Visual grading analysis of three delayed phase images using an injector showed good results, with a total score of 9 for detail and contrast, as assessed by a radiology specialist.

#### 3.1.1.4. Results of the delay phase assessment with a syringe



**Figure 4.** Arterial Syringe Phase

Based on the results of the assessment by a radiology specialist regarding Figure 3.1.1.4. can be seen on Table 4

**Table 4.** Based On Visual Grading Analysis of Aspects of Detail, Contrast, And Sharpness

No	Patient Code	Contrast Method	Anatomical Detail	Contrast	Sharpness	Total Score
1	P01	Spuit	3	3	3	9
2	P02	Spuit	3	3	3	9
3	P03	Spuit	3	3	3	9

Delayed phase images obtained using a manual syringe were rated as 'good' by the radiology specialist, with a total score of 9 for detail and contrast.

**Table 5.** Wilcoxon test VGA score artery phase and delay phase injector method

Wilcoxon Test	Value	Information
VGA Score Artery Phase and Delay Phase	1.000	No difference

Based on Table 5, the results of the Wilcoxon test between the artery and delay phases in the injector group mean: There is no significant difference between the VGA scores of the artery and delay phases, because  $p > 0.05$ . This means that visually, the image quality in the artery and delay phases is assessed as equally good by radiologists in the injector group.

**Table 6. Wilcoxon Test VGA Score Artery Phase And Delay Phase Syringe Method**

Wilcoxon Test	Value	Information
VGA Score Delay Phase and Artery Phase	0.083	No difference

Based on Table 6, the results of the Wilcoxon test between the artery and delay phases in the syringe group mean: There is no significant difference between the VGA scores of the artery phase and the delay phase in the syringe group, because  $p > 0.05$ .

**Table 7. Mann-Whitney U test comparing injector and syringe methods in the arterial phase**

Mann-Whitney-U Test	Value	Information
VGA Score Artery Injector Phase dan Sduit	0.025	Different

Based on Table 7, the results of the Mann-Whitney U comparison of the injector and syringe methods in the artery phase show a significant difference between the image quality (VGA score) of the artery phase produced by the injector and syringe methods. Since  $p < 0.05$ , this means that visually, there is a significant difference in the image quality in the artery phase using the injector and syringe methods.

**Table 8. Mann-Whitney U Test Comparing The Injector and Syringe Methods with Delayed Phase**

Mann-Whitney-U Test	Value	Information
VGA Score Delay Injector Phase dan Sduit	1.000	No difference

Based on Table 8, the results of the Mann-Whitney U comparison of the injector and syringe methods in the delay phase showed no significant difference between the image quality (VGA score) of the delay phase produced by the injector and syringe methods. Since  $p > 0.05$ , this means that visually, the image quality in the delay phase of the injector and syringe methods were assessed as equally good by radiologists.

### 3.2. Discussion

The MSCT abdomen contrast examination begins with patient preparation, including allergy screening and kidney function tests, followed by the administration of oral and intravenous iodine-based contrast agents. The IV agent is delivered using an automatic injector at a volume of 100–120 mL, a flow rate of 2.5 mL/s, and a scan delay of 70 seconds (Seeram, 2016).

The MSCT Abdomen contrast examination technique uses IV contrast media via an injector with a multiphase technique consisting of the late arterial phase, venous phase, and delayed phase (Melikian et al., 2016). The arterial phase evaluates arterial anatomy and is the initial phase that occurs after a delay of approximately 15-40 seconds (Endrikat et al., 2018). Corticomedullary or venous phase to evaluate venous phase anatomy and reveal enhancement in the renal cortex, starting approximately 30-40 seconds after contrast media injection (Irfan Irfan & Rahmat Widodo, 2024). The delay phase is used to optimize visualization of certain organs and tissues, especially in detecting and evaluating abnormalities in the liver, blood vessels, and urinary tract, starting approximately 300 seconds post-injection (Wijokongko et al., 2017).

The contrast-enhanced abdominal MSCT examination at the Radiology Department of PKU Muhammadiyah Gamping Hospital was performed using two contrast media injection techniques intravenously, namely using an automatic injector and manually with a syringe. The contrast media used for these two methods is non-ionic, with a volume of 50 mL and a contrast concentration of 350 mg I/mL. The injector delivered contrast at a flow rate of 3.5 mL/s, followed by 40 mL of saline. The

arterial phase was acquired 25 seconds after contrast injection, while the delayed phase was acquired 5 minutes post-injection. While manual injection without saline, the arterial phase was taken after the manual injection was completed, and the delay phase 10 minutes post-contrast media injection.

In the injector group, the Wilcoxon test showed no significant difference between the arterial and delayed phase VGA scores ( $p = 1.000$ ), indicating that the visual quality of the images in both phases was relatively similar for patients who received contrast media using the automatic injector.

In the syringe group, the Wilcoxon test showed no significant difference between the arterial and delayed phases ( $p = 0.083$ ), indicating that the visual quality of the images in the arterial and delayed phases was not significantly different for patients who received contrast media using the manual syringe.

The Mann-Whitney U test for the arterial phase showed a significant difference between the injector and syringe methods ( $p = 0.025$ ), with the injector method providing visually better image quality than the syringe method.

The Mann-Whitney U test for the delayed phase showed no significant difference between the injector and syringe methods ( $p = 1.000$ ), indicating that the visual quality of the images in the delayed phase of the injector and syringe methods was visually assessed as equally good by radiologists.

In the author's opinion, there is a significant difference for the arterial phase between the automatic injector and the manual syringe, while for the delay phase there is no significant difference between the automatic injector and the manual syringe. From the results of the study, the arterial phase using the injector provides better image quality, while the delay phase using the injector and syringe both provide good image quality, so that for the delay phase using the syringe is sufficient to provide good image quality and is a solution for BHP (Consumables) due to the significant cost difference between the injector and the syringe.

#### 4. Conclusion

Abdominal contrast-enhanced MSCT examinations at the Radiology Department of PKU Muhammadiyah Gamping Hospital were performed using two contrast media injection techniques intravenously: using an automatic injector and manually using a syringe. The contrast media used for both methods was non-ionic, with a volume of 50 mL and a contrast concentration of 350 mg I/mL. The injector used a flow rate of 3.5 mL/s and 40 mL of saline. The arterial phase was drawn 25 seconds after contrast injection and 5 minutes after the delay phase. The manual injection without saline was drawn after the manual injection and 10 minutes after the delay phase.

In the arterial phase, the HU values differed significantly between the automatic injector and manual syringe injection methods, with the injector method providing better contrast enhancement quality. There was a significant difference in the image quality of the arterial phase using the automatic injector and manual syringe, while there was no significant difference in the delay phase between the automatic injector and manual syringe. The arterial phase using an injector provides better image quality, while the delayed phase using an injector and a syringe both provide good image quality. Therefore, for the delayed phase using a syringe is sufficient to provide good image quality and is a solution to BHP (Consumables) due to the significant cost difference between injectors and syringes.

This research is expected to provide a basis for determining the best method for improving image quality in contrast-enhanced abdominal MSCT examinations and to improve the Standard Operating Procedure (SOP) for contrast-enhanced abdominal MSCT examinations in accordance with the latest literature.

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## References

- Afriani, D. (2024). *Buku Ajar Epidemiologi Penyakit Tidak Menular*. Penerbit NEM.
- Choi, M., Lee, Y., & Jung, S. (2022). The Image Quality and Diagnostic Performance of CT with Low-Concentration Iodine Contrast (240 mg Iodine/mL) for the Abdominal Organs. *Diagnostics*, *12*(3), 752. <https://doi.org/10.3390/diagnostics12030752>
- Endrikat, J., Barbati, R., Scarpa, M., Jost, G., & Ned Uber, A. E. (2018). Accuracy and Repeatability of Automated Injector Versus Manual Administration of an MRI Contrast Agent-Results of a Laboratory Study. *Investigative Radiology*, *53*(1), 1–5. <https://doi.org/10.1097/rli.0000000000000403>
- Flynn, W., & Vickerton, P. (2025). *Anatomy, Abdomen and Pelvis: Abdominal Wall*.
- Francis, I. R., Cohan, R. H., McNulty, N. J., Platt, J. F., Korobkin, M., Gebremariam, A., & Ragupathi, K. I. (2003). Multidetector CT of the liver and hepatic neoplasms: effect of multiphasic imaging on tumor conspicuity and vascular enhancement. *AJR. American Journal of Roentgenology*, *180*(5), 1217–1224. <https://doi.org/10.2214/ajr.180.5.1801217>
- Irfan Irfan, & Rahmat Widodo. (2024). Tatalaksana Pemeriksaan CT Scan Abdomen Dengan Kontras Dengan Klinis CA Recti. *DIAGNOSA: Jurnal Ilmu Kesehatan Dan Keperawatan*, *2*(1), 113–123. <https://doi.org/10.59581/diagnosa-widyakarya.v2i1.2711>
- Koshi, R. (2025). 153The abdominal cavity. In R. Koshi & R. Koshi (Eds.), *Cunningham's Manual of Practical Anatomy Volume 2 Thorax and Abdomen* (p. 0). Oxford University Press. <https://doi.org/10.1093/med/9780198939016.003.0013>
- Li, S., Yuan, X., Yi, Z., Dai, H., Yang, L., Dai, Z., & Yan, G. (2023). Dual-phase contrast-enhanced multislice computed tomography scans play a key role in the diagnosis of abdominal wall desmoid-type fibromatoses. *Technology and Health Care: Official Journal of the European Society for Engineering and Medicine*, *31*(S1), 45–54. <https://doi.org/10.3233/THC-236005>
- Li, X.-M., Reng, J., Zhou, P., Cao, Y., Cheng, Z.-Z., Xiao, Y., & Xu, G.-H. (2014). Solitary fibrous tumors in abdomen and pelvis: imaging characteristics and radiologic-pathologic correlation. *World Journal of Gastroenterology*, *20*(17), 5066–5073. <https://doi.org/10.3748/wjg.v20.i17.5066>
- McDermott, M., Kemper, C., Barone, W., Jost, G., & Endrikat, J. (2020). Impact of CT Injector Technology and Contrast Media Viscosity on Vascular Enhancement: Evaluation in a Circulation Phantom. *The British Journal of Radiology*, *93*(1109), 20190868. <https://doi.org/10.1259/bjr.20190868>
- Melikian, R., Goldberg, S., Strife, B. J., & Halvorsen, R. A. (2016). Comparison of MDCT protocols in trauma patients with suspected splenic injury: superior results with protocol that includes arterial and portal venous phase imaging. *Diagnostic and Interventional Radiology (Ankara, Turkey)*, *22*(5), 395–399. <https://doi.org/10.5152/dir.2016.15232>
- Paparo, F., Garelo, I., Bacigalupo, L., Marziano, A., Galletto Pregliasco, A., Rollandi, L., Puppo, C., Mattioli, F., Puntoni, M., & Rollandi, G. A. (2014). CT of the abdomen: degree and quality of enhancement obtained with two concentrations of the same iodinated contrast medium with fixed iodine delivery rate and total iodine load. *European Journal of Radiology*, *83*(11), 1995–2000. <https://doi.org/10.1016/j.ejrad.2014.07.010>
- Seeram, E. (2016). *Computed Tomography: Physical Principles, Clinical Applications, and Quality*

*Control* (F. Edition (ed.)).

Trigui, M., Ouanes, Y., Rahoui, M., Chaker, K., Marrak, M., & Nourira, Y. (2023). Massive hydronephrosis due to obstruction by upper urinary tract urothelial carcinoma with compression of the inferior vena cava. *Urology Case Reports*, 50, 102539. <https://doi.org/10.1016/j.eucr.2023.102539>

Wijokongko, A., Pudyastuti, S., & Widiyanto, A. (2017). Pengaruh fase pemeriksaan MSCT multiphase terhadap gambaran lesi hepar. *Jurnal Teknologi Kesehatan*, 7(2), 101–108.