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“Pseudothrombus” of the Inferior Vena Cava
A Normal Finding on CT with Bolus Injection in the Foot Vein

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下大静脈 CT スキャンにおける“Pseudothrombus”について

—下肢静脈からの急速注入造影法—

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下大静脈血栓症の検索には下肢静脈からの急速注入造影 CT スキャンが有用とされている。われわれは同法により、正常下大静脈も血栓症と紛らわしい像を呈する事を観察した。

15例の正常下大静脈を深吸气相、深呼气相でそれぞれ3例ずつ、残り9例は両呼吸相でスキャンした。3種の造影パターンが得られ、それぞれ homogenous パターン、layered パターン、pseudothrombus パターンと分類した。homogenous パターンは深吸气相で3例、深呼气相で6例に、layered パターンは深吸气相のみ7例に、pseudothrombus パターンは深吸气相で2例、深呼气相で6例にみられた。

layered および pseudothrombus パターンは

homogenous パターンに比べて、その平均面積が大きい下大静脈に観察され、造影剤と血液の混合が不十分な場合、および内腔を満たす造影剤の量が不十分な場合に生じると考える。深吸气相では横隔膜によって下大静脈は狭窄され腹部下大静脈の血流は緩徐となり、血液より比重の高い造影剤は下層に沈む事により、層状形成を生じると推定する。深呼气相では腹部下大静脈の血流は速くなり、層状形成の乱れを生じ pseudothrombus を呈する。2例で深吸气相に pseudothrombus パターンを呈したが、これは血流が緩徐になる程、十分な吸気相でなかったと考えられる。

CT スキャンにおける下大静脈血栓症の診断には、これらの正常造影パターンに留意を要する。

Introduction

Many radiological studies have been performed to diagnose the thrombosis of the Inferior Vena Cava (IVC). These techniques were vena cavography, radionuclide angiography¹⁾, ultrasonography²⁾, and so

on.

Since computed tomography (CT) has been introduced as a tool of radiological procedure, this technique has been also utilized and proven to be one of the most useful methods for the detection of this disease^{3,7)}. These findings are known as filling defect, inhomogenous density, rim enhancement and enlargement of IVC⁶⁾. These signs are more clearly observed by the utilization of contrast agent with bolus administration via foot vein to expect sufficient concentration into IVC^{3,7)}. Occasionally, CT scan with direct cannulation of femoral vein with bolus injection was performed⁶⁾.

Now, during our clinical routine procedures with foot vein bolus injection, we often observed inhomogenous opacification of the IVC in normal cases using the third generation CT scanner. The purpose of this report is to classify normal opacification patterns of IVC with foot vein bolus injection on CT finding, and to call attention to these normal findings must not be misinterpreted as a thrombus.

Materials and Methods

All CT examinations were performed with Siemens Somatom 2 scanner using a slice thickness of 8 mm at the condition of 125 kVp, 230 mA with 5 sec. scan time. The machine was calibrated with CT phantom before all investigations. Consecutive slices of IVC of the patients were obtained before, and after 5 min. during drip infusion of 50ml meglumine iothalate (Conray). A bolus injection of 50ml meglumine iothalate was performed before the drip infusion study. Intravenous administration of contrast agent was made in the medial marginal vein of the foot with 19-gauge scalp vein needle. The CT values of IVC on pre-enhanced and enhanced scans were measured as "region of interest" which we made, consisted of 84 to 384 pixels with a mean of 184.

As the cases of normal IVC, 15 patients who were referred for retroperitoneal CT scans were evaluated. None of the patient had an abnormal anatomy and/or physiology of the IVC such as paracaval mass, cardiac failure, and so on. They were 13 males and 2 females, and their ages ranged from 37-62 years with the mean at 51. Consecutive slices of infra-hepatic segment of the IVC were obtained. Sixty per cent of meglumine iothalate was given 13 cases, and 30% of meglumine iothalate was administrated in 2 cases. All patients retained their breath at full-inspiration on scan both before and during drip infusion. Taking the images of CT with bolus injection, three of each case retained their breath at full-inspiration, and full-expiration, respective. The remaining 9 cases retained their breath at both full-inspiration and full-expiration.

Both area and ratio of minimum diameter to maximum diameter of the IVC which were obtained by bolus injection were also measured using electronic cursor.

In the case of the IVC thrombosis study, a forty-seven year-old male with right renal cell carcinoma was examined by CT to evaluate the existence of a tumor thrombus in the IVC. Consecutive slices were examined from the hepatic portion downward along the IVC. Sixty per cent of meglumine iothalate was also administrated by drip infusion as well as bolus injection via foot vein for enhanced study. In all scans for this patient, the breath was held at the full-inspiratory phases.

























Results

Normal IVC studies

The density of IVC on precontrast CT scan ranged from 40 to 47 with the mean value of 42 Hounsfield units (H.). The IVC images using foot vein drip infusion at full-inspiration, "homogenous" opacification was shown in 12 cases, while the other 3 cases (NO.1,12,14), contrast agent was observed mainly in the lower portion of IVC, and noted as inhomogenous distribution as it is shown in Fig. 4A. The CT values of "homogenous" opacified IVC with drip infusion ranged 89 to 116 averaging 97 H.

The opacification patterns of 15 cases on CT scans with bolus injection in the foot vein were classified into three patterns as they are summarized in Table. 1. We may designate these patterns as "homogenous", "layered" and "pseudothrombus" opacification. "Homogenous" opacification (Fig. 1A,B) was observed in 2 cases on scan at full-inspiration, and 6 cases at full-expiration. "Layered" opacification

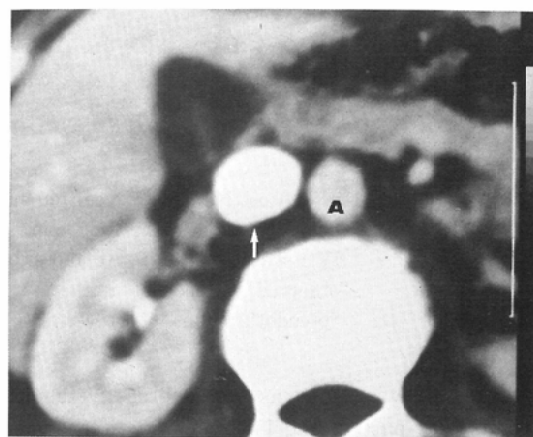
Table 1 Opacification patterns of normal IVC on CT examination with foot vein bolus injection

PATIENT NO.	AGE/SEX	CONTRAST AGENT (MEGLUMINE IOTHALAMATE)	AT FULL-INSPIRATION	AT FULL-EXPIRATION
1	37, M	60 %		
2	40, M	60 %		
3	34, M	60 %		
4	40, M	60 %		
5	57, F	60 %		
6	60, M	30 %		
7	52, F	60 %		
8	62, M	60 %		
9	44, M	60 %		
10	60, M	60 %		
11	51, M	60 %		
12	50, M	60 %		
13	60, M	60 %		
14	51, M	30 %		
15	62, M	60 %		

Representation of CT values with Hounsfield units (H.)

 70-100 H.
  100-200 H.
  200-300 H.


1A



1B

Fig. 1 Case No. 7, A 52 year-old female. A magnified CT view of contrast enhancement with bolus injection in the foot vein. A: At full-inspiration, "homogenous" opacified pattern was seen in the IVC. B: Also "homogenous" opacified IVC was noted at full-expiration and was more distended than that at full-inspiration. Arrow: IVC, A: aorta

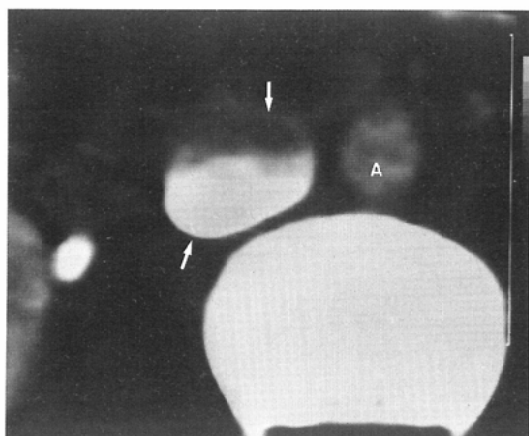
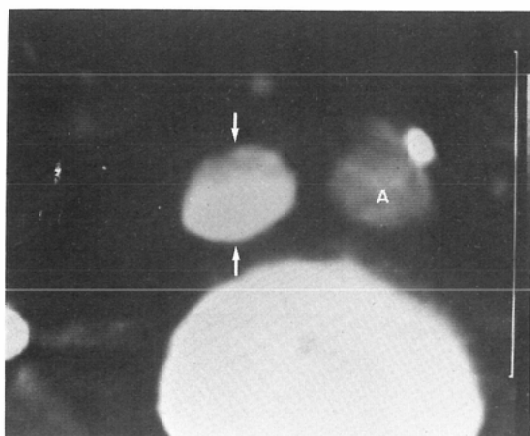
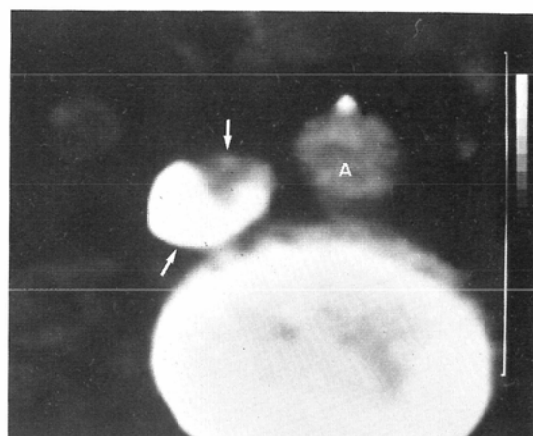


Fig. 2 Case No. 1, A 40 year-old male. A magnified view of CT scan with bolus injection in the foot vein. This demonstrated "layered" pattern of opacified IVC, and shows three layered at full-inspiration. Arrow: IVC, A: aorta



3A



3B

Fig. 3 Case No. 11, A 51 year-old male. A magnified view of contrast study with bolus injection in the foot vein. A: At full-inspiration, "layered" opacified IVC was seen. B: At full-expiration, peculiar shaped low density area observed at upper left in the IVC adjacent to the level of A. and classified as "pseudothrombus". arrow: IVC, A: aorta

(Fig. 2,3A) was shown as two or three layers with higher CT values in the lower part and lower CT values in upper part of the IVC. This pattern was noted in 7 cases at full-inspiration and none at full-expiration. "Pseudothrombus" opacification (Fig. 3B, 4A,B) was shown as the forms with wedged or various peculiar shaped low density area in the IVC lumen as they are often seen in the case of IVC thrombosis. This pattern was noted in 2 cases at full-inspiration and 6 cases at full-expiration.

The opacification patterns both at inspiratory and expiratory phases were compared in 9 cases in this studies. Four cases showed the same pattern in both phases. These included 2 cases with "homogenous" opacification (NO.7,8) and 2 cases with "pseudothrombus" opacification (NO. 9,12). Different patterns were noted in 5 cases between both phases. The patterns were as follows: Two cases showed "layered" at full-inspiration and "pseudothrombus" at full-expiration (No. 10,11). The other 2 cases had a "layered"

Table 2 The areas and Min/Max ratio of IVC on CT scan with foot vein bolus injection

Patient no.	At full-inspiration		At full-expiration	
	Area (mm ²)	Min/Max ratio*	Area (mm ²)	Min/Max ratio*
1	380	0.70		
2	287	0.72		
3	294	0.80		
4			204	0.56
5			207	0.65
6			331	0.56
7	200	0.55	219	0.71
8	467	0.52	416	0.62
9	244	0.60	249	0.50
10	268	0.64	277	0.71
11	228	0.73	224	0.67
12	186	0.52	176	0.54
13	298	0.73	278	0.56
14	286	0.80	284	0.62
15	253	0.42	254	0.44

Min/Max ratio*: The ratio for the minimum diameter to the maximum diameter of the IVC.

pattern at full-inspiration and a "homogenous" one at full-expiration (NO. 13, 14). The remaining case showed "homogenous" at full-inspiration and "pseudothrombus" at full-expiration (NO.15).

Both area and ratio for the minimum diameter to the maximum diameter (Min/Max ratio) in the IVC which were obtained on scan with bolus injection were listed in Table 2. The average area of IVC was 261mm². And the areas of IVC in "homogenous", "layered" and "pseudothrombus" patterns were measured as a ranged of 200 to 284mm², 228 to 380mm² and 176 to 467mm² with the mean values of 205, 292, and 287mm², respectively. The Min/Max ratio of IVC was measured with mean value of 0.62. And the respective values of these ratios were ranged from 0.42 to 0.71 with mean of 0.58 in "homogenous" pattern, 0.64 to 0.80 with mean of 0.73 in "layered" pattern and 0.44 to 0.71 with mean of 0.57 in "pseudothrombus" pattern.

These ratios were compared in 9 cases both in inspiratory and expiratory phases as indicator for dilatation of the IVC. Well dilated IVC were observed both in full-inspiratory and full-expiratory phases. And no marked difference was observed between these two phases concerning the size of IVC.

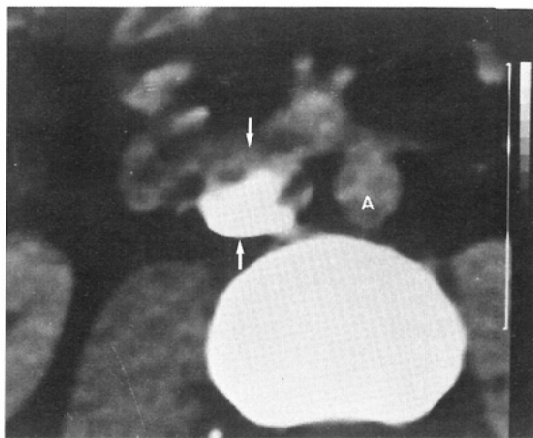
The case study for IVC thrombosis

The case study of IVC thrombosis due to renal tumor, CT images showed large mass extended to the anterior portion of right kidney with dilated IVC on precontrast scan. On enhanced scan at the same level, both with drip and bolus foot vein injection, rim enhancement and filling defect were clearly shown as the signs of thrombus (Fig. 5A). At the level of right renal vein, inhomogenous opacified IVC with irregular shaped low density area with the CT value of 80 H. was observed on scan with bolus injection (Fig. 5B). At the level of inferior portion of the liver, abnormal finding of IVC was hardly detected with drip infusion technique (Fig. 5C). However, with bolus injection filling defect with CT values of 74 H. was obviously noted (Fig. 5D).

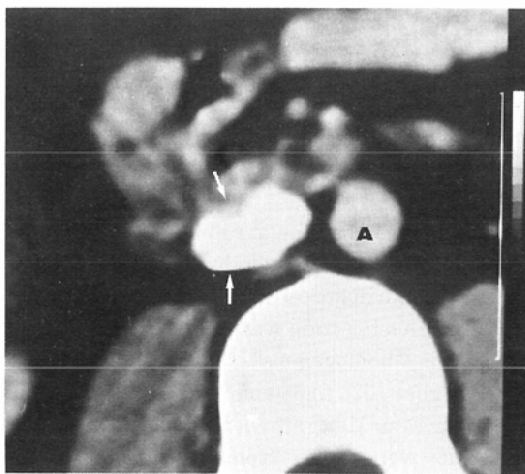
Surgical exploration revealed the intracaval thrombus due to direct invasion of the renal tumor. And the tumor thrombus were extended to the IVC at the level of the inferior portion of the liver, although the IVC at the level of the right renal vein was noted as free of thrombus. These abnormal opacification of IVC at this level on scan with bolus injection may show a pattern similar to the "pseudothrombus" which we classified.



4A



4B



4C

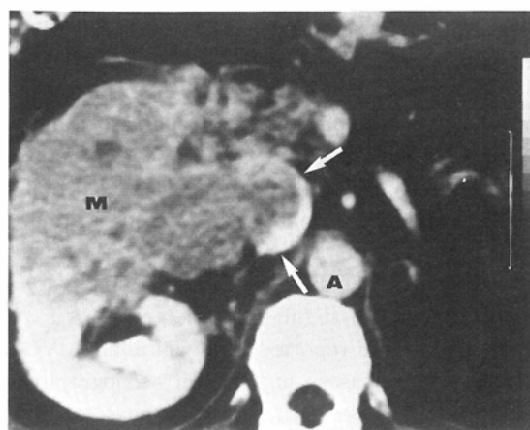
Fig. 4 Case No. 12, A 50 year-old male. A magnified view of the IVC showing. A: During foot vein drip infusion, contrast agent was seen only lower portion of the lumen of IVC. B: With bolus injection in the foot vein at full-inspiration "pseudothrombus" was observed. C: With bolus injection in the foot vein also at full-expiration "pseudothrombus" pattern of IVC was observed. arrow. IVC, A.: aorta

Discussion

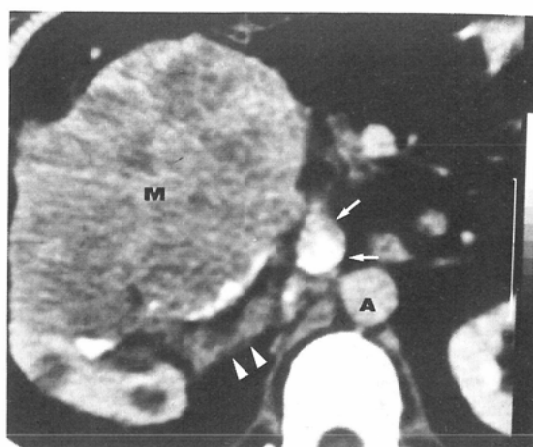
The detection of the IVC thrombosis is important to determine the prognosis and surgical procedure for the disease such as renal cancer⁸⁾⁹⁾. As we described previously many reports have been published in this field using CT scan. However, none of the reports has been noted in normal findings of the IVC with foot vein bolus injection.

In this study, we report the various opacification patterns of normal IVC on scan with bolus injection in the foot vein. They are classified as "homogenous", "layered" and "pseudothrombus" patterns as we described previously. And these normal variations which we have found include the mimicry of intracaval thrombus.

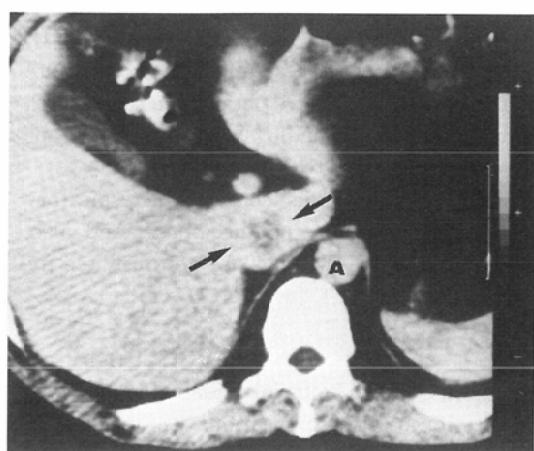
The patterns we described as "pseudothrombus" were inhomogenous opacification. We speculate



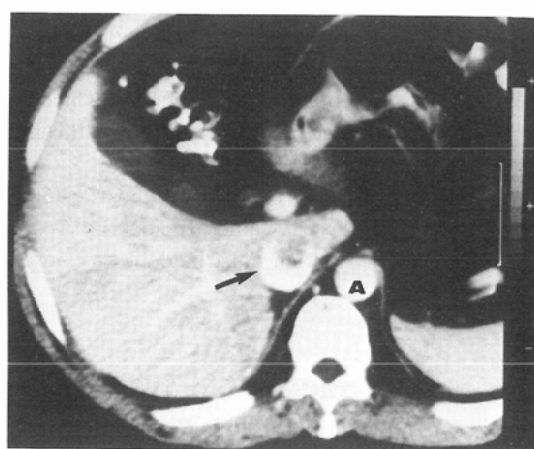
5A



5B



5C



5D

Fig. 5 A 47 year-olds male with the case of renal cell carcinoma. A : A huge mass was observed in the right kidney, and inhomogenous density were clearly shown with bolus injection in the foot vein. B : At the level of right renal vein, inhomogenous opacified IVC with irregular shaped low density was shown on scan with bolus injection in the foot vein. C : At the level of inferior aspect of the liver, abnormal finding of the IVC was hardly detected with drip infusion. D : At the almost same level, filling defect was obviously noted with bolus injection in the foot vein. arrow : IVC, A : aorta, head arrow : right renal vein, M : mass

the reason for these phenomena is insufficient amount of contrast agent for filling up the large IVC lumen. Generally, a contrast agent has a greater specific gravity than that of blood, and has a tendency to deposit in the lower portion of the vessel, if it is insufficiently mixed and/or administered in insufficient amounts.

In our investigation, both "layered" and "pseudothrombus" patterns were observed in dilated IVC. And, the former pattern was noted at full-inspiration, while the latter pattern was noted generally at full-expiration. Now, why were these different patterns observed in normal IVC ? We speculate that the reason may be strongly related to the blood flow in the IVC.

From this standpoint, it is essentially necessary to investigate the physiological flow in the IVC. The relation between respiratory cycles and blood flow in the IVC has been reported by several authors^{10)~12)}. According to these reports, blood flow in the abdominal portion of the IVC decreases at full-inspiration because of the considerable constriction by the diaphragm, whereas the blood flow may be increase at full-expiration. From this knowledge, we suspect that the "layered" pattern is shown in the case of slow blood flow of IVC, and the "pseudothrombus" pattern is shown in rapid blood flow due to turbulence of the blood flow in IVC. In a few cases, "pseudothrombus" pattern were also observed at full-inspiration. In these cases, the patients might not retain their breath at full-inspiration so the blood flow decreases.

The size of the IVC on the CT scan must also be discussed, because the diameter of the IVC may vary with the respiratory phase. Pillari recommends that holding the breath at full-expiration on scan is a useful technique to maintain fully dilated IVC¹³⁾. However, Grant et al reported that well dilated IVC could be obtained on scan at end of both inspiratory and expiratory phases using the ultrasonographic method¹⁴⁾. And also in our CT investigation, well dilated IVC were observed during both phases.

Without contrast enhancement, the tumor thrombus of the IVC has been reported to have CT values of 20 to 50 H., which is similar to that of circulating blood⁴⁵⁾. For this reason, it is necessary to identify the opacification difference between thrombus and normal IVC lumen on CT evaluation more clearly. The CT values of the IVC by routine drip infusion via antecubital vein was reported as range of 60-70 H. as reported by Burgener et al¹⁵⁾. On the other hand, the IVC thrombus with relatively high density were reported using foot vein bolus injection which had almost the same results as we obtained in this study⁷⁾. So, these facts suggest to us that the IVC thrombosis may appear in various findings with different means of enhancement on CT study.

For an evaluation of IVC thrombosis using foot vein bolus injection, we must consider the respiratory phase as well as CT values to identify "pseudothrombus" pattern from true thrombus. And also, sufficient interpretation must be done so that misinterpretation of normal findings are not mistaken for thrombosis.

Conclusion

Normal Inferior Vena Cava (IVC) of 15 cases were studied on CT with bolus injection in the foot vein. Well dilated IVC were obtained on scan both at full-inspiration and full-expiration. As the normal findings of IVC, different opacification patterns which may be designate "homogenous", "layered" and "pseudothrombus" were obtained. The "homogenous" opacification was noted both at full-inspiration and full-expiration. In homogenous patterns as noted as "layered" and "pseudothrombus" were suspected to occur in the case of insufficient mixing of contrast agent with blood and/or insufficient amount of contrast agent. And both these patterns were observed in dilated IVC. The "layered" opacified IVC was shown on scan at full-inspiration at which respiratory phase the blood flow in IVC may decrease. The "pseudothrombus" pattern was generally noted at full-expiration at which the blood flow may increase.

Although bolus injection of contrast agent into foot vein is useful for evaluation of IVC, one should be aware of normal opacification of IVC including "pseudothrombus" pattern.

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