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Abdominal, Thoracic and Peripheral Angiography with An Angiographic System of High Maneuverability

Mutsumasa Takahashi[1], Hiromasa Bussaka[1], Masayuki Miyawaki[1] and Takeshi Nakanishi[2]

[1]Department of Radiology, Kumamoto University School of Medicine, 1-chome, Honjo, Kumamoto, 860, Japan

[2]Shimazu Seisakusho, Ltd., Kawahara-cho 1, Nakakyo-ku, Kyoto, 604, Japan

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高操作性血管造影システムによる腹部，胸部，四肢血管造影

熊本大学医学部放射線医学教室（主任：高橋睦正教授）

高橋　睦正　　仏坂　博正　　宮脇　正行

島津製作所医用機器事業部（主任：向坂光雄部長）

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血管造影から詳細な情報が得られ，合併症や被曝線量が減少し，かつ最近注目されている interventional angiography にも対応できる操作性の高い血管造影装置を開発した．

本装置はC字型のガントリーを有し，アイソセンターを中心に体軸回り135度の回転，頭尾方向に±30度の角度がとれるように設計した．2個の回転陽極X線管に対し，受像系として2組の螢光増倍管と連続撮影装置を配した．X線管の1つには，0.2mm の双焦点（焦点間距離40mm）と1.0mm の焦点を含み，他のX線管は1.0mm の双焦点（焦点間距離63mm）と0.2mm の焦点を有する．

本装置により立体撮影，拡大撮影，2方向透視，2方向 DSA などが可能になり，迅速に透視と撮影を切り換えることも可能となった．腹部，胸部，頸部，骨盤部，四肢の血管造影を本装置を用いて行ったので，本装置の構造，性能と共にその有用性を報告する．

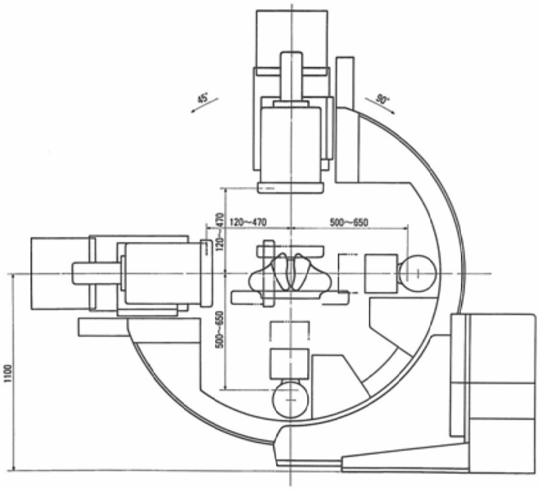
With recent widespread use of intraarterial DSA and interventional techniques during angiographic procedures, the angiographic unit or system should have capabilities of expedicious perfomance of DSA and interventional angiography in addition to various conventional angiographic techniques. One of the most important items for such capabilities is probably availability of biplane DSA, biplane and oblique fluoroscopy and rapid switchover between fluoroscopy and radiography. Of course, conventional angiographic techniques should also be available, including stereoscopy, magnification and stereoscopic magnification.

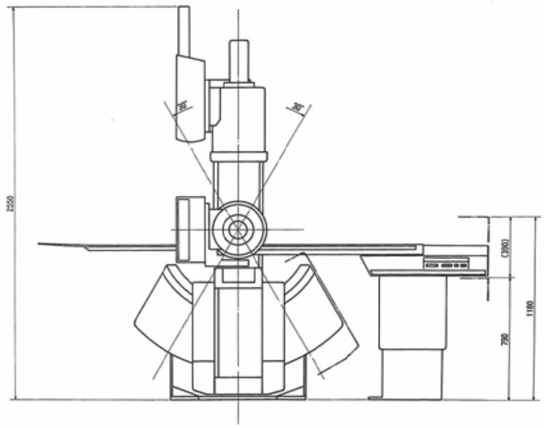
In 1982, we reported an angiographic unit which is capable of various angiographic techniques such as biplane stereoscopic magnification and rapid switchover between fluoroscopy and radiography[1)~5)]. This unit has received wide acceptance, but several limitations have been observed[3)6)].

Angiographic System

Isocentric gantry:

The system has a "C" type gantry which rotates and angulates around its isocenter (Figs. 1 and 2). The



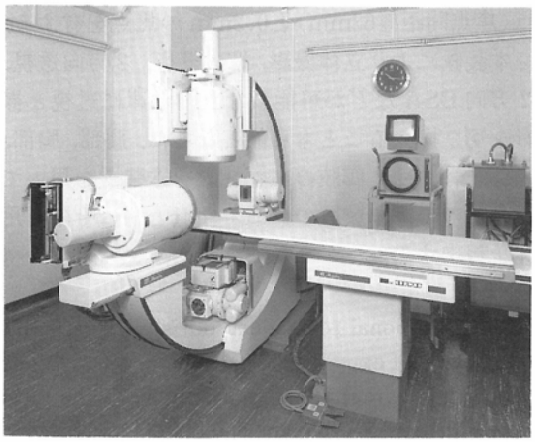


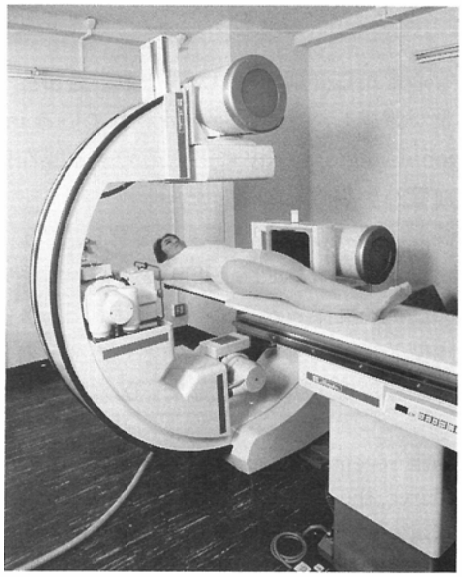
1A 1B

Fig. 1 Schematic diagram of the unit.

A: The unit as seen from the direction of the angiographic table.

B: Side view of the unit.





2A 2B

Fig. 2 General view of the unit.

A: Set-up for biplane fluoroscopy. Switchover from fluoroscopy to radiography is rapid in 6 seconds.

B: Set-up for PA stereoscopic magnification angiography. The horizontal or lateral tube is utilized.

gantry rotates 90 degrees clockwise and 45 degrees counterclockwise as seen from the side of the angiographic table. The gantry angulates anteriorly or posteriorly 30 degrees. Ninety degree rotation is completed in 14 seconds and 30 degree angulation in 10 seconds. Two sets of an X-ray tube and an imaging assembly (an image intensifier and a rapid film changer) are mounted on the gantry at horizontal or lateral position as well as at vertical or anteroposterior position.

X-ray tubes:

Two heavy duty rotating anode X-ray tubes are mounted on the gantry at the horizontal or lateral position and the vertical or anteroposterior position. The horizontal X-ray tube has 0.2 mm twin focal spots (4.0 cm distance) for stereoscopic magnification angiography and a 1.0 mm single focus for monoplane contact angiography. The anteroposterior X-ray tube harbors 1.0 mm twin focal spots (6.3 cm distance) for stereoscopic contact angiography and a 0.1 mm single focus for monoplane magnification anigography. Fluoroscopy and DSA are carried out with use of 1 mm focus of the X-ray tubes. Each tube has maximum anode heat content of 750 KHU. The maximum kilowatt rating is 72 kW for each X-ray tube, the exposure factor being 90 kV and 800 mA at 0.1 second.

The X-ray tubes can be moved 15 cm toward or away from the isocenter to adjust the focal film distance (FFD).

Imaging assembly:

On the opposite side of each X-ray tube, a set of an image intensifier and a rapid film changer (imaging assembly) is attached. The size of the image intensifier is 9 inch with switchover to 7 inch. The TV camera is of plumbicon type with a diode gun, whose signal to noise ratio is more than 1000:1.

The rapid film changer can be loaded with 20 sheets of 14 × 14 inch films and the maximum film-transport speed is 4 per second. Therefore, the film-transport of 2 per second is available for alternate biplane angiographic series.

The image intensifier and the rapid film changer can be exchanged in 6 seconds.

The imaging assembly can be moved for 35 cm toward or away from the isocenter in 14 seconds to adjust the FFD. The horizontal imaging assembly can be deviated 30 degrees aside for more room in the front area for the brachial angiographic procedure and general anesthetic procedure or for more space on the side of angiographic table for direct puncture cerebral angiography.

Angiographic table:

The table is made of carbon fiber to reduce X-ray absorption. The height of the table is adjustable between 79 cm and 118 cm. The longitudinal stroke of the table is 170 cm, while the horizontal stroke is 24 cm within the gantry.

The table can be mechanically moved stepwise in 4 increments for a distance of 22.5, 24.5 or 26 cm for peripheral angiography.

Control panel:

Various movements of the unit can be controlled on the control panel within the angiographic room. The rotation and angulation of the gantry, table height and FFD can be adjusted on this panel. Freezing of the angiographic table, fluoroscopy and radiography can be controlled as well. In addition, the degree of rotation and angulation, FFD as well as magnification factor at the isocenter of the system are displayed digitally on the control panel.

Function of the System

Contact angiography:

Various monoplane angiographic projections can be obtained with conventional and stereoscopic techniques (Table 1). Oblique or angulated projections are easily obtainable. In addition, biplane angiography can be performed with or without aid of stereoscopic techniques when necessary. Change from contact

Table 1 Abdominal, Thoracic and Peripheral Angiography by the system

I. Contact angiography
1. Stereoscopic contact angiography
2. Routine contact angiography
3. Biplane contact angiography
4. Switchover between magnification and contact angiography in isocentric position
II. Magnificaiton angiography
1. Biplane or single plane stereoscopic magnification angiography
2. Non-stereoscopic magnification angiography
3. Oblique stereoscopic magnificaiton or half axial stereoscopic magnification angiography
4. Magnificaiton factor changed up to 2.5 times
5. The table not elevated for magnification angiography
III. Fluoroscopy
1. Biplane fluoroscopy
2. Oblique fluoroscopy
3. Biplane DSA
4. Rapid change between fluoroscopy and radiography
IV. Other functions
1. Angiography of extremity by "step"method
2. Maximum of four films per second for single plane angiography
3. Easier anesthetic procesures because of "C" gantry
4. Increased maneuverability
5. Accurate measurement of vessel diameters,distances and angles

angiography to magnification angiography or to fluoroscopy is expediciously performed.

Magnification angiography:

Magnification angiography can be performed with or without stereoscopic techniques in any desired X-ray beam direction (Table 1). The angiographic table need not be elevated for magnification angiography, since the FFD can be changed with the patient in the isocenter. The maximum magnification factor is 2.5 times, while 1.3 to 2.1 times is the magnification factor available at the isocenter.

DSA and flouroscopy:

Fluoroscopy and DSA in the desired projections can be obtained as necessary (Table 1). Biplane fluoroscopy and DSA can be performed without shifting or moving the patient. Switchover from fluoroscopy to radiography is simple and expedicious. Biplane fluoroscopy is particularly useful not only for interventional angiography, but also for non-angiographic interventional techniques and needle biopsies. DSA in stereoscopy is obtainable.

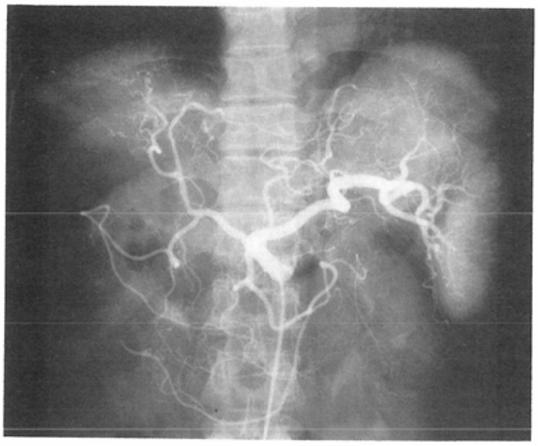
Other function of the unit:

Peripheral angiography is performed easily with use of this system (Table 1). Angiography via brachial route and general anesthetic procedures can be performed without difficulty, because the gantry has a "break" or is of "C" type. There is more room in the front area by deviation of the imaging assembly at the lateral position. Measurements of the vessel diameter, the distance between two points and the angle formed by two lines can be determined accurately[4].

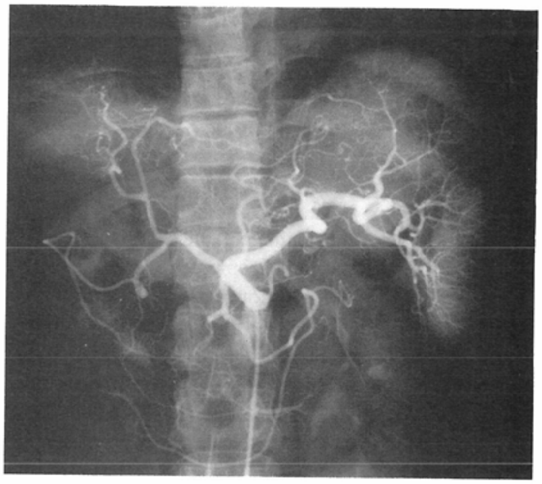
Results

The angiographic system described in this report was used in angiography of the thorax, abdomen, and extremities for a variety of vascular and tumorous disorders. Normal small arterial branches as well as minimal vascular and tumorous abnormalities were demonstrated to good advantage with use of conventional, stereoscopic and magnification techniques (Fig. 3).

Stereoscopic contact angiography was routinely used as the first step, followed by stereoscopic magnification, intraareterial DSA or oblique or angulated projections as clinically indicated (Fig. 4). Biplane angiographic series were also obtained for the angiograms of the extremities and the thorax of the adults and



3A



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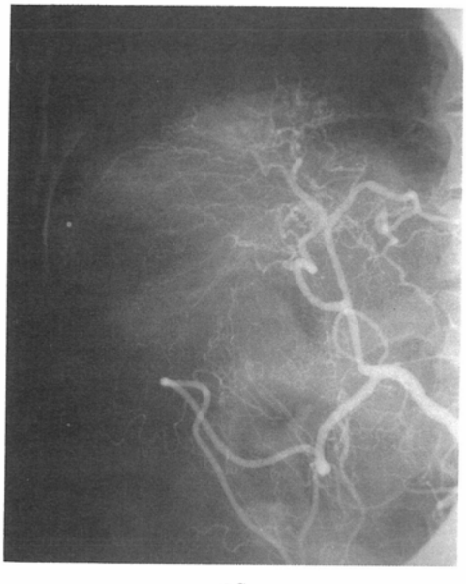
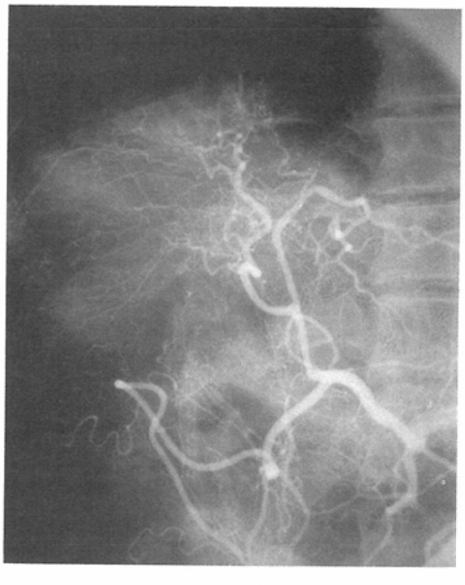
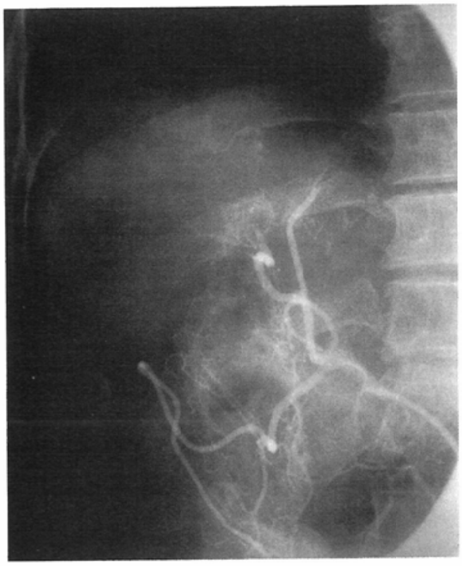


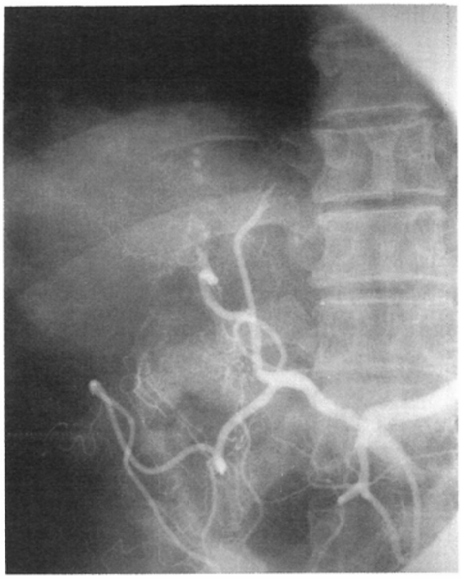
3C



3D

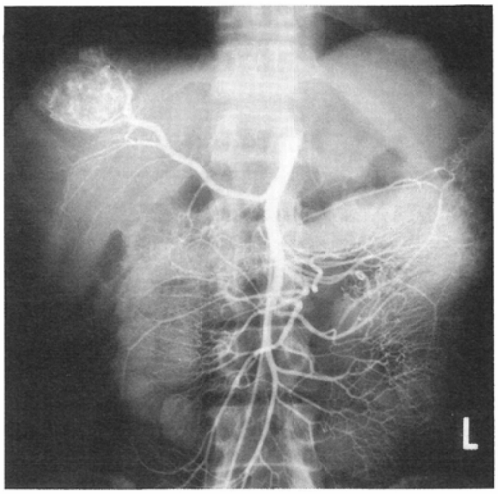


3E



3F

Fig. 3 Hepatoma in the superior portion of the right lobe in a 61-year-old female.
A, B: stereoscopic celiac angiogram. Tumor vessels supplied by the right hepatic artery are well shown stereoscopically. Enlargement of the spleen and the left lobe of the liver is seen.
C, D: Stereoscopic magnification angiogram of the right hepatic artery. The tumor vessels and the blood supply to the tumor are clearly shown stereoscopically.
E, F: Stereoscopic magnification angiogram following embolization. The hepatic artery occlusion is well shown on stereoscopic viewing.



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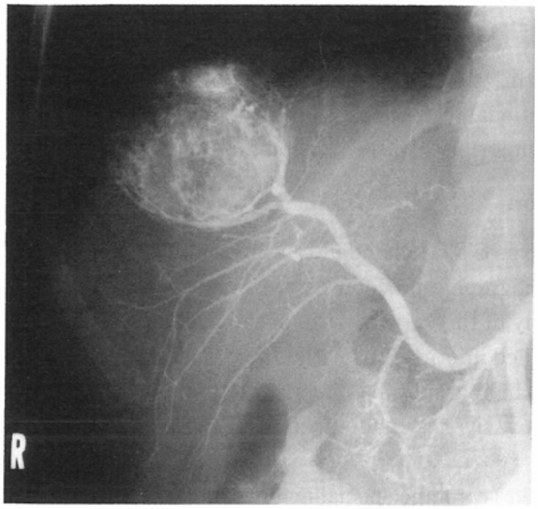

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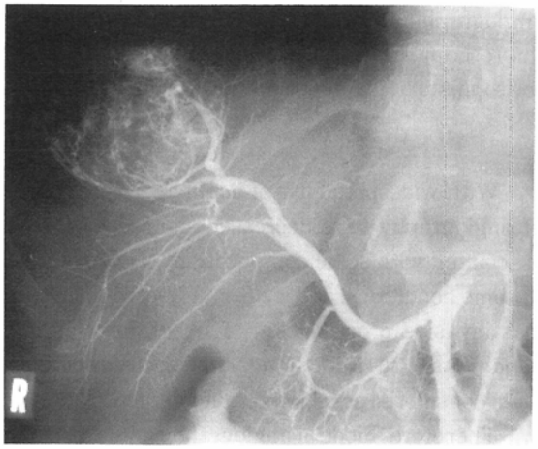

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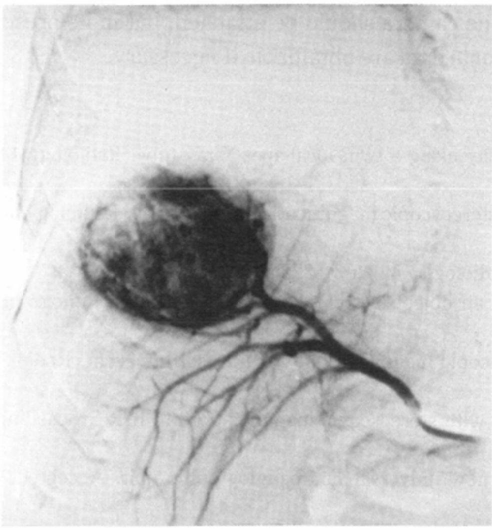
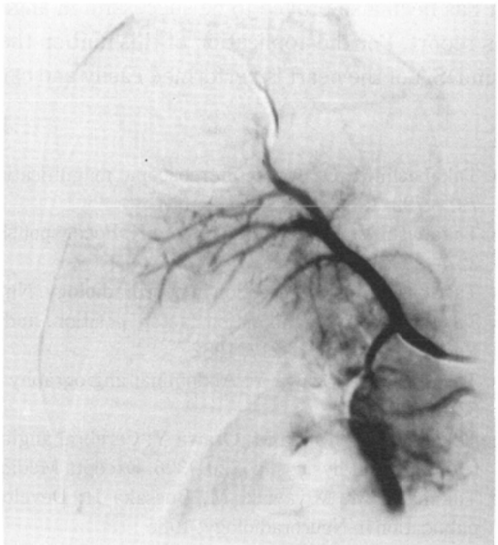


4D



4E

Fig. 4 Hepatoma of superior, anterior segment of the right lobe in a 41-year-old male.

A: Stereoscopic angiogram of the superior mesentric artery. The right hepatic artery arises from the superior mesentric artery and supplies the tumor. The tumor is localized in the superior, anterior segment of the right lobe.

B, C: Magnification stereoscopic angiogram with selective injection of the right heaptic artery. The tumor is well shown with tumor vessels and stains. The tumor and its supplying vessels are visualized stereoscopically.

D: DSA with intraaterial injection. The tumor stains and the supplying vessels are well shown.

E: Intraaretial DSA after embolization with gelfoam. The tumor stains are not shown and the occluded vessels are visualized quite well.

for most angiograms of small children.

Switchover among fluoroscopy, DSA and radiography was done easily and expediciously, facilitating angiographic procedures significantly, especially in utilization of interventional techniques. Biplane fluoroscopy and DSA were particularly useful for interventional techniques. In our hands, the time required for sophisticated interventional angiography was reduced almost up to 50% by using this unit.

Discussion

With widespread use of noninvasive examinations such as CT, MRI and ultrasonography, the indications of angiography have decreased significantly because angiographic procedures are somewhat invasive and associated with some complications. However, angiography of the various parts of the body is still essential in some conditions, and is often expected to give more detailed informations with lower complication rate and less invasive procedures[3)6)]. Furthermore, interventional angiography has been widely applied to various conditions. From the standpoint of costeffectiveness, nonivasiveness and speed of performance, DSA has been considered as an important adjunct to angiography.

Therefore, modern angiographic system should be able to combine special angiographic techniques such as magnification and stereoscopy, but also must incorporate capabilities of biplane DSA, biplane fluoroscopy and rapid switchover among DSA, fluoroscopy and radiography[3)6)]. The system described in this report has been developed to satisfy most of the requirements of a modern angiographic equipment.

The system was originally developed for use in neuroangiographic procedures with excellent results[7)], but has been also proved to be successful in angiography of other parts of the body as has been described in this report. For the application of this unit on the heart, a cine camera should be attached, but in its present form DSA of the heart is performed easily and cardiac functional data are obtainable if necessary.

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