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ULTRASOUND GUIDED CATHETERISATION OF INTERNAL JUGULAR VEIN VERSUS BLIND CATHETERISATION USING ANATOMICAL LANDMARKS IN CRITICALLY ILL PATIENTS– A COMPARATIVE STUDY

General Surgery

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ABSTRACT

Introduction Central venous catheterization (CVC) is a crucial component of patient treatment in critical care. Rapid intravenous access is necessary for administering fluids, administering inotropes, administering medications, taking blood for tests and administering parenteral nutrition[1]. Traditional landmark method is associated with high rates of failures (35%) and complications (26%)[2,3]. Use of ultrasound (USG) guidance is recommended to reduce these rates [4,5,6]. This study will report our experience with internal jugular vein catheterisation by ultrasound (USG) guided and landmark method in terms of number of attempts, catheter related inflammation, mechanical complications and early removal due to complications. **Materials And Methods** This was a prospective study of 30 months (March 2021- August 2023) which included 200 patients in whom central line cannulation was done in intensive care units at MMIMSR, Mullana. The patients were equally divided into Group A and Group B of 100 patients each selected by random computerization and central internal jugular line was inserted by landmark method and USG guided method, respectively. Time taken, number of attempts, catheter related inflammation, catheter related complications, catheter tip culture on removal and early removal due to adverse effects were noted for both methods and were compared by appropriate statistical methods. **Results** In our study, USG guided central line insertion showed significant reduction in terms of time to insertion (8.1 mins versus 11.7 mins), number of attempts (p-value = 0.0001), incidence of catheter site inflammation (p-value=0.0001), incidence of mechanical complications (p-value=0.0001), rate of positive tip culture on removal (p-value=0.002) and need for early removal of catheter(p-value=0.0001). **Conclusion** Ultrasound-guided technique for insertion of central line catheter in internal jugularvein is superior over the landmark landmark technique.

KEYWORDS

Central Venous line, ultrasound, landmark

INTRODUCTION

A reliable central venous access is necessary for treatment and resuscitation in critically ill patients. Intensive care unit rely heavily on central venous access for advanced hemodynamic monitoring, blood sampling, fast fluid infusion and the administration of specific drugs and parenteral nutrition[1].

By using recognisable anatomical landmarks, the internal jugular vein have historically offered dependable and simple vascular access[7]. The vein is punctured either by using the landmark method (when external anatomical landmarks are used) or by using ultrasound (US) using Seldingers technique[8].

The anatomical landmark method is shown to have a high rate of failure (35%) and complications (26%)[2,3].Use of ultrasound guidance has shown to reduce the complication rate and increase the success rate of central venous catheterization[4].

In view of these findings Agency for Healthcare Research and Quality, the National Institute for Health and Clinical Excellence in the UK, the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists have advocated the use of ultrasound for central venous catheters placement[5,6]

AIMS AND OBJECTIVES

The purpose of this study was to compare ultrasound guided and landmark based central venous catheterization of internal jugular vein in terms of

1. The success rate.
2. Average number of attempts.
3. Average time to the return of blood
4. Incidence of port site inflammation.
5. Incidence of complications like arterial puncture, pneumothorax and hematoma formation.
6. Incidence of early removal (< 7 days) of CVC due to complications.
7. Incidence of positive tip culture after removal.

MATERIALAND METHODS

Study Population And Sample Size

This was a prospective study of 30 months (March 2021- August 2023) which included 200 patients in whom central line cannulation was done in surgical intensive care units at MMIMSR, Mullana. An informed patient consent was obtained. Patients were randomly (computer generated randomization) divided into two groups, group A (n=100) included patients the CVC placement was done under the guidance of ultrasoundand group B (n=100) included patients who underwent CVC insertion with the landmark technique.

Inclusion Criteria

Adult patients admitted in surgical ICU in need of central venous cannulation.

Exclusion Criteria

Patients with known bleeding or clotting disorders.
Patients with trauma and pneumothorax or fracture clavicle with local hematoma.
Patients with open wound or infection at cannulation site.
Burns' patients.

Technique

Landmark Technique

Patients were placed in 15 degrees Trendelenburg position and the skin at the entry site was disinfected with 2% solution of chlorhexidine and was covered with sterile drape. Medial border of the sterno cleidomastoid muscle and the pulsations of the carotid artery serve as anatomical landmarks of Internal Jugular Vein.

The catheterization needle attached to a 5ml syringe with 2ml ringers solution was slowly advanced to the expected position of the vein with continuous suction applied with the syringe. After the return of the venous blood in the syringe, the needle guide was inserted and the procedure was finished according to the Seldinger's technique [8].

USG METHOD

A linear transducer 5 to 10 MHz was used. Asepsis was achieved with sterile gel and sterile cover for the probe. The ultrasound probe was applied on the lateral aspect of the neck in a 90-degree angle to the long

axis of the internal jugular and the needle for catheterization was inserted at the middle of the long axis of the probe to achieve a short axis out of plane approach [5].

With this approach the needle is shown as a hyperechoic dot on the US-monitor while the venous and arterial vessels are shown as hypoechoic oval and circular structures with well-defined borders. The vein is centered into the middle of the screen and the needle was carefully advanced under ultrasound guidance until the anterior wall is punctured and venous blood is aspirated in the syringe connected to it. After documenting the return of the venous blood the Seldinger's technique for catheterization was used[8].

Study Design

The placement of the CVC was done in internal jugular vein for each group under aseptic precautions by the same team by Seldinger technique. The time taken, success rate, number of attempts and mechanical complications were recorded for both groups.

Time was measured from skin puncture to return of venous blood. A maximum of four attempts were allowed at the catheter site after which the procedure was declared unsuccessful. Mechanical complications like arterial puncture, pneumothorax and hematoma were recorded.

A pulsatile flow of bright red blood from the needle was a sign of arterial puncture. In such cases the needle was withdrawn from the skin and manual pressure was applied until hemostasis was achieved.

Hematoma formation on the skin access site bigger than 1 cm in diameter was recorded. A radiographic examination of the lungs was made 6 hours after the procedure to check the catheter's position and check for pneumothorax.

Patient was followed up for the signs of catheter site inflammation. Cases where early removal (within 7 days) of catheter was needed due to complications were also recorded. Catheter tip was sent for culture in all the cases post removal.

RESULTS

The study included 200 patients divided into two groups. The average age of the patients inthe ultrasound group was 59.3 years and the average age of the patients in the landmark groupwas 59.2 years. The statistical difference between the groups for the average age is not significant (Table and Diagram 1). Male and female patients were equally represented in both groups. Both groups were homogenous regarding gender and age(Table and Diagram 2) .

Table 1. Mean age of patients the two groups

	Group-B Ultrasound Guided (n=100)	Group A Control group (n=100)	t - value	p value
Age (M/±SD)	59.3 ± 12.42767	59.2 ± 12.83163	0.06729	0.955

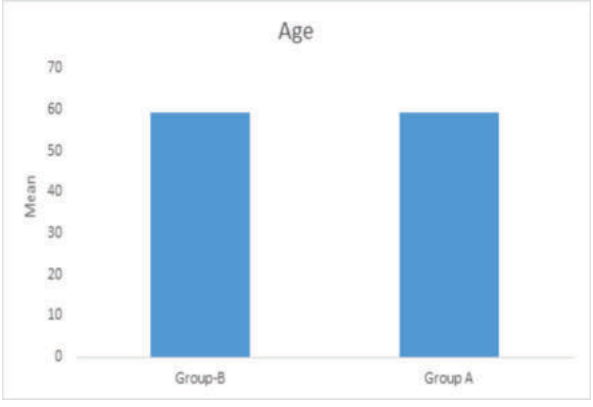

Diagram 1. Mean age of patients in the two groups

Table 2. Gender distribution in the two groups.

	Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Chi square	p - value
Male	60	60.0%	52	52.0%	1.299	.254
Female	40	40.0%	48	48.0%		

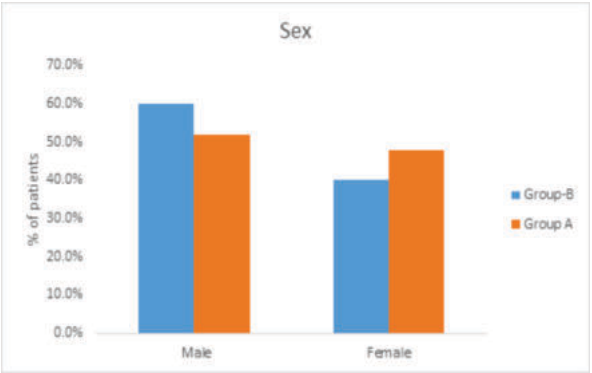

Diagram 2. Gender distribution in the two groups.

In our study, we observed that mean time taken for central line cannulation by USG guided method is 8.1 min whereas in landmark method mean time taken is 11.7 min (Table and Diagram 3).

Table 3. Time taken (in mins) for cannulation in the two groups.

		Method						Chi-Square	P -value
		Group-B Ultrasound-Guided (n=100)		GROUP A (Landmark)		Total			
Time (min)	6.00-7.59	30	30.0%	34	34.0%	64	32.0%	11.753	.008**
	8.00-9.59	50	50.0%	30	30.0%	80	40.0%		
	10.00-11.59	16	16.0%	22	22.0%	38	19.0%		
	>=12.00	4	4.0%	14	14.0%	18	9.0%		
	Total	100	100.0 %	100	100.0%	200	100.0 %		

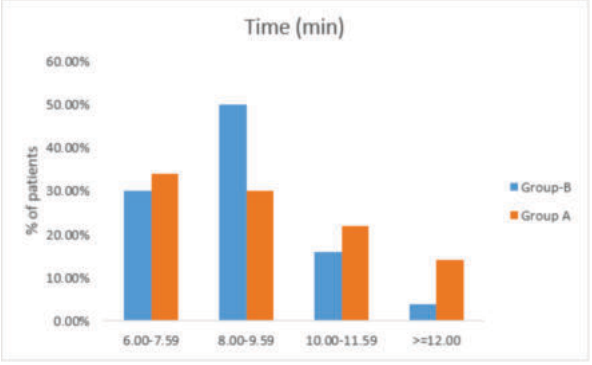

Diagram 3. Time (in mins.) taken for cannulation in the two groups.

In our study, USG guided central line insertion was successfully done in one attempt in 92% of the patients (46 patients); whereas by landmark method, only 68% were successful in one attempt (34 patients). It was seen that the number of successful first attempts was significantly more in the USG guided group (p-value = 0.0001**). (Table and Diagram 4)

Table 4. Number of attempts required for successful cannulation in the two groups.

		Method						Chi-Square p-value	
		Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Total			
Attempts	One	92	92.0%	68	68.0%	160	80.0%	18.472	.0001**
	Two	6	6.0%	20	20.0%	26	13.0%		
	Three	2	2.0%	10	10.0%	12	6.0%		
	Four	0	0.0%	2	2.0%	2	1.0%		
	Total	100	100.0%	100	100.0%	200	100.0%		

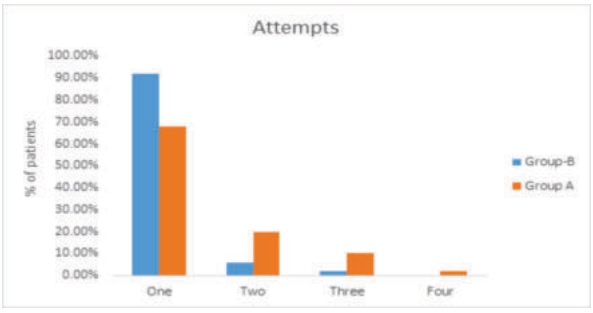

Diagram 4. Number of attempts required for successful cannulation in the two groups.

Catheter related complications were noted while and after insertion of central line in adult patients under the heading pneumothorax, arterial puncture and hematoma formation.

Pneumothorax was noted in total 6 patients out of 100 in which 1 patient was in USG guided group (2%) and 5 patients were in landmark group (10%). It was statistically significant (p-value= 0.016)

Arterial puncture was seen in total 7 patients out of which 1 was in USG guided group (2%) and 6 were in landmark group (12%). It is statistically significant (p-value= 0.005).

In our study hematoma were seen in total 3 patients and all were in landmark group (6%). Its statistically significant (p-value= 0.012)

Patients (96%) experienced no such complications with USG guided method and it is statistically significant with p value of 0.0001 (Table and Diagram 5).

Table 5. Number of cases of mechanical complications in the two groups.

		Method						Z -proportion	p -value
		Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Total			
Complications	Pneumothorax	2	2.0%	10	10.0%	12	6.0%	2.42	.016*
	Arterial puncture	2	2.0%	12	12.0%	14	7.0%	2.83	.005**
	Hematoma	0	0.0%	6	6.0%	6	3.0%	2.53	.012*
	No	96	96.0%	72	72.0%	168	84.0%	4.90	.0001**
	Total	100	100.0%	100	100.0%	200	100.0 %		

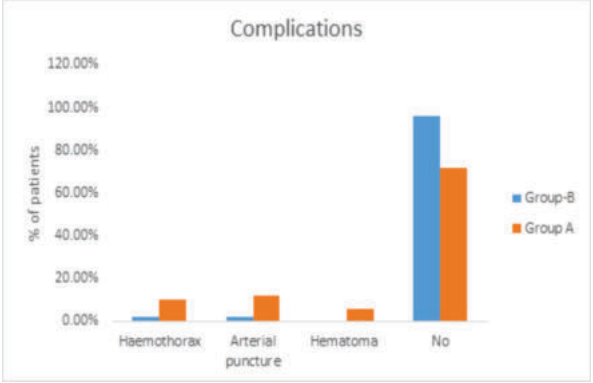

Diagram 5. Incidence of mechanical complications in the two groups.

Catheter related inflammation were noted after insertion of central line catheter under headings of pain, induration, redness and pus discharge. Out of 200 patients, 20 patients had pain after central line insertion. In USG guided method, only 12 patients had pain (2%) whereas in landmark method 18 patients had pain (18%). The data was statistically significant (p-value = 0.0001).

Induration was seen in 18 patients in present study out of 200 patients. It was seen in 2 patient in USG guided method (2%) and in landmark method it was seen in 16 patients (16%). It was statistically significant (p-value=0.0001).

Redness was seen only in 16 patients around catheter; 4 patients from USG guided group (4%) and 12 patients from landmark group (12%). It was significant statistically (p-value = 0.035).

Pus discharge from catheter site was seen in 12 patients, out of which 2 was in USG guided group (2%) and 10 was in landmark group (10%). It was significant statistically (p-value = 0.016).

Overall, insertion was complication in 90 patients in USG group (90%) and 62 patients in land mark group (62%) which is also statistically significant (p-value=0.0001) (Table and Diagram 6).

Table 6. Number of cases showing catheter related inflammation in the two groups.

		Method						Z -proportion	p-value
		Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Total (n=200)			
Catheter Inflammation	Pain	2	2.0%	18	18.0 %	20	10.0 %	3.91	.0001**
	Induration	2	2.0%	16	16.0 %	18	9.0%	3.57	.0001**
	Redness	4	4.0%	12	12.0 %	16	8.0%	2.11	.035*
	Pus Discharge	2	2.0%	10	10.0 %	12	6.0%	2.42	.016*
	No Inflammation	90	90.0%	44	44.0 %	134	62.0 %	7.93	.0001**
	Total	100	100.0 %	100	100.0%	200	100.0 %		

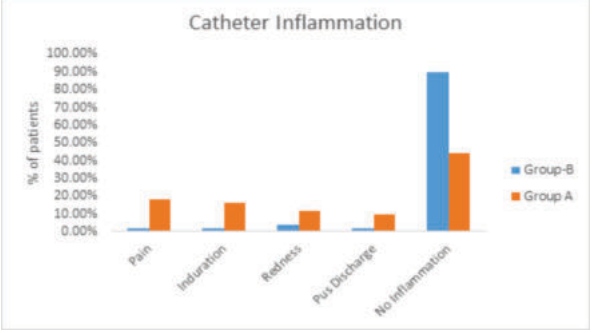

Diagram 6. Incidence of catheter related inflammation in the two groups.

In our study After removal of catheter, catheter tip was sent for culture. Tip culture were positive in 22 patients, out of which 4 were from USG guided group (4%) and 18 were from landmark group (18%). It was statistically significant (p-value = 0.002) (Table and Diagram 7)

Table 7. Number of cases showing positive tip culture after removal of CVC in the two groups.

		Method						Chi-Square	p -value
		Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Total (n=200)			
Catheter related infection (TIP Culture)	Positive	4	4.0%	18	18.0 %	22	11.0 %	10.010	.002**
	Negative	96	96.0%	82	82.0 %	178	89.0 %		
	Total	100	100.0%	100	100.0 %	100	200.0%		

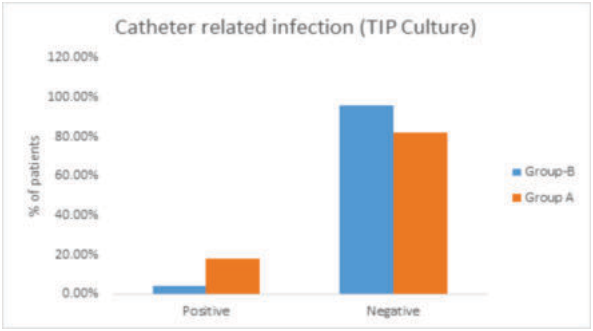

Diagram 7. Incidence of positive tip culture after removal of CVC in the two groups.

Normally Central line is kept for 14 days. Central line was removed early (within 7 days) in 34 patients due to complications out of which 4 patients were from USG guided method (4%) and 30 patients were from landmark method (30%). It was statistically significant with p-value of 0.0001(Table and Diagram 8).

Table 8. Number of cases requiring early removal of CVC in the two groups.

		Method						Chi-Square	p-value
		Group-B Ultrasound-Guided (n=100)		Group A Landmark (n=100)		Total (n=200)			
Early Removal due to Adverse Effects	Yes	4	4.0%	30	30.0%	34	17.0%	23.955	.0001**
	No	96	96.0%	70	70.0%	166	83.0%		
	Total	100	100.0%	100	100.0 %	200	100.0 %		

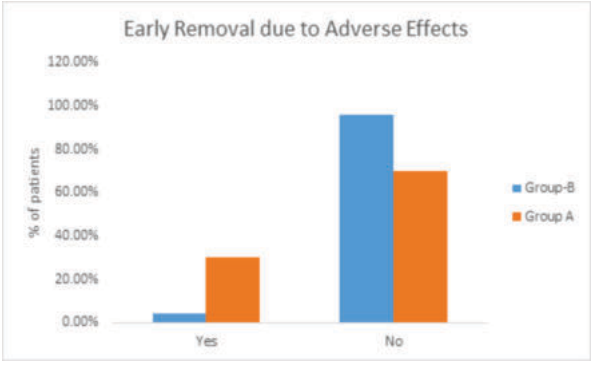

Diagram 8. Incidence of early removal of CVC in the two groups.

DISCUSSION

For two methods, USG guided and landmark, there are many studies to compare convenience and complications during central line cannulation. Present study was done to check the efficacy of different modalities in central venous cannulation by ultrasound and landmark methods in adult patients with undertaking several parameters such as time, number of attempts, catheter related inflammation, catheter related complications and early removal due to adverse effects.

In our study we observed that mean time taken for central line cannulation by USG guided method is 8.1 min whereas in landmark method mean time taken is 11.7 min.

It was seen that the number of successful first attempts was significantly more in the USG guided group 92% as compared to 68% in landmark method (p-value = 0.0001**). While in USG guided group success rate was 100% by third attempt it was 98% in landmark group. These results are consistent with previous studies by M Fragou et al ($p < .05$) [9], Karakitsos et al ($p < 0.001$) [10], V Prabhu et al ($p = 0.000$)[11], JY Lefrant et al (OR=3.6) [12], Sou Chen Chew et al ($p = 0.01$) [13], CD Froehlich et al (p=0.001)[14]. Although different authors took different definitions of time to insertion, all of them showed significant reduction in time to cannulation and reduced number of attempts by use of ultrasound.

Catheter related inflammation were noted after insertion of central line catheter under headings of pain, induration, redness and pus discharge. In our study, in USG guided method, only 2% patients had pain as compared to 18% in landmark method (p-value = 0.0001). Induration was seen in 2% patients in USG guided method and in 16% patients landmark method (p-value=0.0001). Redness was seen in 4% patients from USG guided group and 12% patients from landmark group (p-value = 0.035). Pus discharge from catheter site was also significantly less in USG guided group (2%) as compared to landmark group (10%) (p-value = 0.016).

Overall, incidence of catheter site inflammation was 10% in USG group as compared to 38% patients in land mark group (p-value=0.0001).

These results showed an overall increased rate of catheter related inflammation in our study as compared to previous studies like GD Jaramillo et al (0.6%) [15], L Cavanna et al (9.96%) [16], Safdar N et al (3.18%) [17]. However, the results are consistent with decreased rates of catheter site inflammation by use of USG as seen in studies conducted by Imataki O et al [18], Hind D et al [19], Leung J et al [20], Miller AH et al[21]. Decreased time to cannulation and decreased number of attempts can be the contributing factors for the decreased incidence of catheter site inflammation in the USG group. In turn, such inflammation can be a source of significant morbidity to the patient and may also increase the rate of catheter infections and early removal of catheter.

Catheter related complications were noted while and after insertion of central line in adult patients under the heading haemothorax, arterial puncture and hematoma formation. Incidence of pneumothorax was significantly less USG guided group (2%) as compared to landmark group (10%) (p-value= 0.016). Arterial puncture was seen in 2% patients in USG guided group and 12% in landmark group (p-value= 0.005). In our study hematoma were seen in 6% patients and all were in landmark group (p-value= 0.012). Overall, significantly increased number of patients (96%) showed a complication free insertion in the USG guided group versus landmark group (72%) (p-value= 0.0001)

GB Palelpu et al [22], JM Smit et al [23], GD Jaramillo et al [15] found similar results in their studies where in significantly increased rates of complications in landmark method as compared to USG guided method. Direct visualisation of vein offered by USG, as compared to a blind placement in landmark group, might be the factor responsible for decreased chances of misplacement of the catheter to the pleura/artery/subcutaneous plane resulting in decreased incidence of complications.

Normally Central line is kept for 14 days. Number of cases requiring early removal (within 7 days) in was significantly lower (4% patients) in USG guided method as compared to landmark method (30%) (p-value of 0.001). This may be attributed to decreased local complications and catheter infections associated with USG guided method. However, no study has actually studied the co relation or compared the rates of early removal in the two techniques. Early removal of central line necessitates placement of a second line at an alternate site and therefore an additional procedure. Thus, increasing the patient morbidity.

Similarly, in our study after removal of catheter, catheter tip was sent for culture. Tip culture were positive in 4% were from USG guided group and 18% from landmark group (p-value = 0.002). Authors like Picardi M et al [24], Takahiro Hosokawa MD et al [25] have tried to study the role of USG in diagnosis of catheter and catheter related blood stream infections. Takeshita J et al [26] did a meta analysis of four randomised controlled trials and found that ultrasound-guided central venous catheterization was associated with a slightly lower incidence of catheter-related bloodstream infections (risk ratio, 0.46; 95% confidence interval [CI], 0.16-1.32) and was not associated with a lower incidence of catheter colonization (risk ratio, 1.36; 95% CI, 0.57-3.26).

However, very few studies have compared the incidence of catheter related blood stream in the two techniques[18]. As such, not much data is available regarding comparison of the rates of catheter infection and catheter related blood stream infection in the two methods. These conditions are known complications of central venous catheterisation and is associated with significant morbidity and even mortality, once it leads to sepsis and septic shock. Further studies are needed to compare

the two methods in terms early removal of catheter and catheter and catheter related blood stream infections.

CONCLUSION

Use of ultrasound guidance in placement of central venous cannulation of internal jugular vein in intensive care patients leads to significantly better results in terms of success rates, number of attempts, catheter related local inflammation and mechanical complications. It also significantly reduces the rate of catheter infections and need for early removal of catheter, hence, decreasing the morbidity associated with jugular cannulation. Therefore, it should be considered the preferred technique for the placement of internal jugular catheter wherever, the facility and expertise is available.

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