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Securing Central Venous Access and Arterial Cannulation in a COVID ICU- Our Experience Questionnaire Based Survey

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Abstract: *INTRODUCTION*: PPE for contact protection is an integral component of the management of critically ill COVID-19 patients. It causes restrictions in mobility and impaired touch perception. This is further impaired by additional standard barrier precautions taken for sterility. In an era where the point of care ultrasound (POCUS) has become an everyday practice, ultrasound guidance is recommended to overcome some of these difficulties. *OBJECTIVE*: The objective was to find and evaluate the techniques practiced, the difficulties faced and complications while performing a central venous catheter and arterial cannula insertion. *MATERIALS AND METHODS*: The study was conducted through an online survey. The questionnaire included questions about the practices followed, the problems faced, and complications during performing such procedures. *RESULT*: 66.66% of the Senior residents and 16.6% of the Consultants attempted the CVC insertions. Arterial cannulation was attempted by 78.37% senior residents and 14.42% Consultants. Majority of intensivists used USG for CVC insertions (86.48%) and for arterial cannulation (81%). The various difficulties faced were impaired vision due to fogging (100%), impaired body movement. 66% complained of suboptimal patient positioning and 33% complained of difficulty in communication during CVC insertion. We found that there were no immediate complications. *CONCLUSION*: To access central and arterial cannulation in a COVID ICU, Senior intensivist should perform the procedure using USG guided techniques so as to improve success rate and minimize complication amidst difficulties like fogging of vision and improper procedural positioning. Standardized equipment for "standard" maximal barrier precautions should be available before performing these procedures in addition to PPE.

Keywords: Central Venous Catheter, Arterial Cannula, COVID-19, ICU, USG

1. Introduction

Intensivists as part of their study curriculum and practical application are well versed in central venous catheter (CVC) insertion and arterial cannulation (AC). The critically ill coronavirus disease of 2019 (COVID-19) patients need CVC due to numerous reasons, such as multiple infusion therapies, administration of vasopressors, drugs incompatible with peripheral venous access, hemodynamic monitoring, repeated venous sampling, poor peripheral access, parenteral nutrition and renal replacement therapy. However these procedures have become technically challenging in this health emergency associated with COVID pandemic. This has lead to formulation of revised protocols and drastic changes in decision making.

COVID pandemic with its mysterious pathology has brought along another challenge i.e. the requirement to wear PPE while providing patient care. Standard PPE along with goggles, face shields is a real challenge to work, with all the heat generation, restriction of movements, decreased sensory perception due to double gloves and the fogging of goggles and face shield. This reduction in the mobility is further

impaired by additional sterility precautions taken while carrying out procedures like CVC and AC insertion where precision and dexterity is required.

To overcome these hurdles, intensivists are trying their level best to use resources and technology so as to minimize shortcomings during CVC and AC insertion. Due to the short history of this disease, little data is available regarding experience in carrying out these procedures. This is important as these feedbacks will help us to improvise, formulate guidelines and use technology to improve patient management.

Our study tries to find out the various methods practiced and the problems faced by intensivist/trainees while performing CVC and AC insertion in our COVID-19 ICU. These experiences will help us in providing a conducive environment both for them and the patient while performing the procedure.

2. Theoretical Background

2.1. Primary Outcome

To find and evaluate the different methods practiced while performing CVC and AC insertion.

2.2. Secondary Outcome

To find out the difficulties faced and complications while performing these procedures.

3. Materials and Methods

The study was conducted through an online survey (using Google forms) utilizing electronic media. Intensivists and intensive trainees who were posted in COVID-19 ICU were sent questionnaire to their email addresses and social media accounts, which was completed and submitted online. The questionnaire was made as a structured document with facility for tick-box format for the most appropriate answer (s). Table 1 and Table 2 showing the questionnaire of the survey. There was also provision for expansion or comments if the intensivist/trainee thought necessary. Intensivist (Consultants and residents) was defined as one who is certified to practice intensive care after completion of their training. Trainee was defined as the one who is currently undergoing training in intensive care.

Table 1. *Shows the questionnaire to assess the methods used and difficulties faced during central line placement.*

To assess the methods used and difficulties faced during central line placement in COVID ICU
(Tick the box ✓ where appropriate)

1. Email address:
2. Name of person performing procedure:
3. Designation: Consultant ☐ Senior Resident ☐ Junior Resident ☐
4. Indication for CVC insertion: Poor peripheral IV access ☐ Vasopressor support ☐
   Hypertonic drug administration ☐ TPN ☐ Other:_____
5. Hand Sterility measures: 2% Chlorhexidine gluconate ☐ 70% Isopropyl alcohol ☐ Extra pair of sterile gloves ☐
6. Procedure Site Preparation: 10% Betadine ☐ 2% Chlorhexidine gluconate ☐
7. Availability of Full body drape Yes ☐ No ☐
8. Technique of Insertion: Landmark ☐ USG guided ☐
9. Optimal patient positioning: Yes ☐ No ☐
10. Site: IJV ☐ SCV ☐ Femoral ☐
11. Side: Right ☐ Left ☐
12. Number of sites attempted: 1 ☐ 2 ☐ > ☐
13. Total number of attempts/ pricks (including all sites attempted): 1 ☐ 2 ☐ >2 ☐
14. Duration of procedure (from parts preparation till dressing): <20mins ☐ 20-30mins ☐ >30mins ☐
15. Confirmation of correct placement during procedure: USG neck ☐ TTE ☐ Both ☐ None ☐
16. Periprocedure PPE used: Goggles ☐ Face Shield ☐ Visor ☐ Linen Gow ☐ Other:____
17. Number of assistants: 1 ☐ 2 ☐ >2 ☐ None ☐
18. Problems faced: Patient positioning ☐ Patient Sedation ☐ Impaired Vision/ Fogging ☐
    Impaired Body Movements due to PPE ☐ Difficulty in communication ☐
    Impaired grip/ handling of equipment ☐ Difficulty in guidewire insernsertion ☐
    Other:_____ None ☐
19. Complications: Arterial puncture ☐ Hematoma ☐ Arrhythmias ☐ Hypotension ☐
    Pneumothorax ☐ Other:_____ None ☐

Table 2. *Shows the questionnaire to assess the methods used and difficulties faced during arterial line placement.*

To assess the methods used and difficulties faced during arterial line placement in COVID ICU

(Tick the box ✓ where appropriate)

1. Email address:
2. Name of person performing procedure:
3. Designation: Consultant ☐ Senior Resident ☐ Junior Resident ☐
4. Indication for arterial line insertion: Hemodynamic monitoring: ☐ Repeated arterial sampling ☐
Coagulopathy ☐ Other:_____
5. Hand Sterility measures: 2% Chlorhexidine gluconate ☐ 70% Isopropyl alcohol ☐ Extra pair of sterile gloves ☐
6. Procedure Site Preparation: 10% Betadine ☐ 2% Chlorhexidine gluconate ☐
7. Availability of Full body drape: Yes ☐ No ☐
8. Technique of Insertion: Palpatory ☐ USG guided ☐
9. Optimal patient positioning: Yes ☐ No ☐
10. Site: Radial ☐ Ulnar ☐ Dorsalis Pedis ☐ Other:_____
11. Side: Right ☐ Left ☐
12. Number of sites attempted: 1 ☐ 2 ☐ >2 ☐
13. Local Anaesthetic given: Yes ☐ No ☐
14. Total number of attempts/ pricks (including all sites attempted): 1 ☐ 2 ☐ >2 ☐
15. Duration of procedure (from parts preparation till dressing) <10mins ☐ 10-20mins ☐ >20 mins ☐
16. Peri procedure PPE used: Goggles ☐ Face Shield ☐ Visor ☐ Linen Gown ☐ Other: _____
17. Number of assistants 1 ☐ 2 ☐ >2 ☐ None ☐
18. Problems faced: Patient positioning ☐ Patient Sedation ☐ Impaired Vision/ Fogging ☐
Impaired body movements due to PPE ☐ Difficulty in communication ☐
Impaired grip/ handling of equipment ☐ None ☐ Other:_____
19. Complications: Difficulty in threading ☐ Hematoma ☐ Embolism ☐ None ☐ Other _____
20. Maintaining the arterial: Intermittent flushing ☐ Using Pressure Bags ☐ Other:_____
21. Compliance of patient post placement: Good and comfortable ☐ Satisfactory ☐ Poor ☐

The questionnaire included questions that dealt with the practices that caregivers followed while performing CVC insertion and arterial cannulation, the problems faced and complications during performing such procedures. At the end of survey, data from the responses to the questionnaire was analyzed using statistical methods relevant to the primary and secondary outcome.

4. Results

The survey was conducted over four months of posting (1st April to 31st July 2020).

4.1. Central Venous Catheter

Of the total central lines inserted, majority of them were inserted by Senior resident (66.66%), and rest were equally distributed between the Consultants and junior resident (i.e. 16.66% each). The most common indication was need for vasopressor support (92.76%), followed by poor peripheral access (4.51%) and dialysis catheter (2.70%). Table 3 showing response of central venous catheter survey.

A Surgical hand scrub was not possible due to prior donning of Personal Protective Equipment (PPE). To ensure patient safety hand sterility measures were taken. Chlorhexidine (0.5%) alcohol hand rub was used in 33.3% procedures and isopropyl alcohol hand rub was used in 66.66% procedures. Additional sterile hand gloves in addition to PPE were used in all procedures. Procedure site asepsis was done with 10% povidone solution in most procedures (92.79%) and 2% chlorhexidine in one case (7.21%). Landmark technique were used in 13.52% and ultrasound guided technique were used in 86.48% of the procedures. Optimal patient position was obtained in 44.15% cases. Internal jugular vein was cannulated in 84.68% patients and subclavian vein in 12.62% and femoral vein in 2.70%. Single site was attempted in 76.57% procedures. The vein was hit in first attempt in 67.56 % and in 2nd attempt in 32.44% patients. Only 2 insertion required second attempts using USG guided technique. Duration of procedure was less than 20 minutes in 66.7% and 20 to 30 minutes in 22.22% and more than 30 minutes in 11.11% cases. The PPE used included goggles, face shield, N-95 respirator mask, coverall, double gloves, shoe cover and additional linen gown in 100% cases.

Table 3. *Shows the responses of Central venous catheter survey.*

Response of the Central Line Placement questionnaire			
Parameter	**Responses (in %)**	**Parameters**	**Response (in%)**
Designation		Number of sites attempted	
Senior Resident	66.66	1	76.57
Junior Resident	16.66	Total number of attempts/ pricks	
Consultant	16.68	1	67.56
Indication		2	32.44
Vasopressor support	92.79	Duration of Procedure	
Dialysis catheter	02.70	<20 mins	66.66
Poor peripheral IV access	04.51	20-30 mins	22.22
Hand sterility measures		>30 mins	11.11
Extra pair of sterile gloves	100	Confirmation of tip	
2% Chlorhexidine gluconate	33.33	None	16.21
70% Isopropyl alcohol	66.66	USG neck	83.79
Procedure Site Preparation		Periprocedural PPE used	
10% Betadine	92.79	Goggles	100
2% Chlorhexidine gluconate	07.21	Face Shield	78.37
Availability of Full Body Drape		Visor	21.63
Yes	72.97	Linen Gown	91.89
No	27.03	Number of assistants:	
Technique of Insertion		1	82.88
Landmark	13.52	>2	17.12
USG guided	86.48	Problems faced:	
Optimal Patient positioning		Patient positioning	66.66
Yes	44.15	Impaired Vision/ Fogging	100
No	55.85	Impaired Body Movements due to PPE	16.21
Site		Impaired grip/ handling of equipment	13.51
SCV	12.62	Patient Sedation	27.92
Femoral	02.70	Difficulty in communication	33.33
IJV	84.68	Difficulty in guidewire insertion	33.33
Side		Complications	
Right	82.88	None	100
Left	28.12		

IV: Intravenous, USG: Ultrasound, SCV: Subclavian vein, IJV: Internal jugular Vein, PPE: Personal protective equipment.

The most common difficulties faced were impaired vision due to fogging in 100% cases. Followed by impaired body movement 16.21% and suboptimal patient positioning in 66.7% procedures. This was followed by difficulty in communication (33.33%), impaired hand grip/equipment handling (13.51%) and difficulty in sedation (27.92%). None of the operators encountered complications during and after the procedure.

4.2. Arterial Cannulation

Most of the arterial cannulations were performed by Senior resident (78.37%), Consultant (14.42%) while 7.21% trainees inserted AC. The most common indication was hemodynamic monitoring (100%). The technique used for cannulation was ultrasound guided (81.08%) and in 18.92% procedure was done by palpatory method. The most common site was radial artery (97.26%) and in 3 patients femoral artery was inserted (2.71%). One site was attempted in most of the cases (85.58%) and more then two sites were attempted in 14.42 patients. Artery was successfully cannulated in first attempt in 18.62% procedures, cannulated in second attempt in 72.07% and more than two attempt were needed in 9.31% patients. The duration of procedure was less than 10 minutes in 71.17% procedures, less than 20 minutes in 19.22% and more than 20 minutes in 9.61%. Goggles, face shield/visor was utilized in 100% of procedures. Table 4 showing the responses of arterial cannulation survey.

The most common problem faced during procedure was fogging (100%) followed by restriction in movement (42.34%). Impaired grip and equipment handling was experienced by 14.41%.

Table 4. *Showing the responses of Arterial cannulation survey.*

Response of the Arterial line placement questionnaire			
Parameter	**Responses (in %)**	**Parameter**	**Responses (in%)**
Designation		Number of sites attempted	
Senior Resident	78.37	1	85.58
Junior Resident	7.21	2	0/0
Consultant	14.42	>2	14.42
Indication		Total number of attempts/ pricks	
Hemodyanamic monitoring	100	1	18.62

Response of the Arterial line placement questionnaire			
Parameter	**Responses (in %)**	**Parameter**	**Responses (in%)**
Repeated arterial sampling	0	2	72.07
Coagulopathy	0/0	>2	09.31
Hand sterility measures	100	Duration of Procedure	71.17
Extra pair of gloves		<10 mins	
0.5% Chlorhexidine gluconate	28.83	10-20 mins	19.22
70% Isopropyl alcohol	71.17	>20 mins	09.61
Procedure Site Preparation		Periprocedure PPE used	
10% Betadine	14.42	Goggles	100
2% Chlorhexidine gluconate	85.58	Face Shield/visor	100
Availability of Full Body Drape		Linen Gown	27.1
Yes	20.67	Number of assistants:	
No	79.33	0	42.34
Technique of Insertion		1	28.83
Palpatory	18.92	2	14.41
USG guided	81.08	3	14.41
Optimal Patient positioning		Problems faced:	
Yes	56.75	Patient positioning	27.92
No	43.25	Impaired Vision/ Fogging	100
Site		Impaired Body Movements due to PPE	42.34
Radial	97.29	Impaired grip/ handling of equipment	14.41
Ulnar	0/0	Patient Sedation	0/0
Femoral	2.71	Difficulty in communication	0/0
Side		Difficulty in guidewire insertion	2.70
Right	42.34	Complications	
Left	57.66	None	100
LA Given		Maitainance of arterial	
Yes	77.47	Pressure bags	100
No	22.53	Intermittent flushing	28.82

USG: Utrasound, PPE: Personal protective equipment.

5. Discussion

The primary outcome of this study was to evaluate various methods practiced for vascular procedures in a COVID-19 ICU. These procedures were carried out in three ICUs' specially dedicated to COVID-19 patients management in a tertiary care hospital in North India where all the moderate to severely ill patients were admitted. Most of the procedures were attempted by Intensivists. 66.66% of the CVC insertions and 78.367% of the arterial cannulation were attempted by Senior resident. Elective vascular procedure like CVC and arterial cannulation should be done by expert professional like consultant, senior resident to improve success rate and minimize complications. Trainees can improve their success rate when supervised by consultant.

Indication for CVC and arterial line varies as per the varied clinical picture. In majority of situation it was used for hemodynamic monitoring. In our survey we found CVC insertion was primarily inserted for infusing vasopressor (92.79%). For prudent and judicious infusion of vasopressor the recommended route is via a CVC. Arterial line was indicated for hemodynamic monitoring in 100% of the patients. Critically ill COVID-19 patients need to have frequent arterial blood gas analysis; the presence of an arterial line reduces the risk of thrombosis and hematoma associated with repeated arterial sampling.

All procedures for vascular access (central venous as well as arterial cannulation) need maximum barrier and asepsis precautions. All procedures should be performed following the CDC recommendations for vascular access in COVID-19 patients. [1] In our ICU, hands were sterilized while performing CVC insertion either with isopropyl alcohol based hand rub (66.66%) or Chlorhexidine alcohol based hand rub (33.33%). This was followed by donning of additional sterile gown and sterile gloves over the donned PPE. For arterial cannulation isopropyl alcohol based hand rub was utilized in 71.17%. For insertion site skin preparation, our ICU intensivists invariably used povidone iodine during CVC insertion (92.79%) and in 85.58% arterial cannulation, chlorhexidine was used. Only in 7.21% of CVC Chlorhexidine was used for site preparation. It is recommended to use 2% Chlorhexidine unless contraindicated in adults. This must be encouraged. However, Maki et al in their randomized controlled trial comparing Chlorhexidine with 10% povidone iodine reported equivocal findings with regards to catheter colonization and related bacteraemia. [2] For Neonates, guidelines recommend to determine the use of Chlorhexidine-containing solutions for skin preparation in neonates based on clinical judgment and institutional protocol. If there is a contraindication to Chlorhexidine, povidone–iodine or alcohol may be used. [3] In one infant patient, povidone iodine was used for skin preparation. Practice guidelines of Central venous access by American Society of Anesthesiologist (ASA) recommend sterile full-body patient drapes involving any vascular procedure. In our survey 72.97% in CVC and 20.67% during arterial cannulation used full body drape. Proper and stringent barrier precautions and measures should be taken for universal implementation of guidelines in all procedures.

Current international guidelines recommend the use of

ultrasound guidance for choosing, puncturing and cannulating the vein and artery. [4] In our survey; intensivists used USG in 86.48% of CVC insertions and 81.08% of arterial cannulation. Overwhelming use of ultrasound in our ICU could be due to two reason. Firstly, due to high humidity, increase summer temperature (sometimes exceeding 40 degree Celsius) and arrangements made to not allow recirculation of ICU air even when air-conditioning is in place made there vision foggy and without the aid of the USG it was like next to impossible to do the procedures leave aside the comfortless in those PPE suits. Superficial structures like radial artery, ulnar artery, IJV, SCV and femoral vessels can be clearly visualized by USG. Secondly, most of the cannulations were done by the Senior consultants who seems to be more comfortable with USG technique in CVC and in arterial cannulation. Amongst trainees the technique used was USG for all the CVC insertion and for arterial cannulation palpatory technique was used. When compared with the anatomic landmark approach, real-time ultrasound guided CVC insertion has a higher first attempt success rate, reduced access time, and decreased complication rates. [5] Reduction in duration of procedure is a very important advantage of ultrasound. Close proximity to a non-intubated patient on high flow nasal cannula during internal jugular and subclavian vein puts us at high risk exposure. Since oxygen therapy with high flow nasal cannula is an aerosol generating procedure. Another reason making ultrasound indispensable is the pathophysiology of COVID-19, where the coagulation system is hyper activated and patients receive concomitant anticoagulation therapy. Similarly there is strong evidence for the use of ultrasound guidance in radial artery cannulation. Ultrasound use significantly increased first-attempt success rate, which subsequently resulted in a significant reduction in the number of attempts and duration of the procedure. [6-8]

In our survey, IJV was catheterized in 84.68 %, subclavian vein in 12.62% and femoral vein catheterized in 2.70%. Insertion site for CVC should be selected based on clinical need. In adults the internal jugular and subclavian vein are most commonly used for access due to potentially lower rates of infection. [9, 10] To minimize the risk of infection, femoral catheterization should be avoided. In case of arterial cannulation, in 97.29% patients radial artery was cannulated. Femoral arterial access was attempted only in pediatric patient after failure to cannulate radial and ulnar arteries and in patients on dialysis. The peripheral arteries like radial, ulnar, dorsalis pedis and axillary are located more easily, and have a lower infection risk compared with central arterial sites. [11] Dorsalis pedis is avoided in patients with peripheral arterial disease and in case of COVID-19 where one of the pathophysiology is thromboembolism and vasculitis, one should restrain from using this site.

During CVC cannulation, provision should be made for real time confirmation of the guide wire residing in the vein throughout the length of neck before using the dilator to dilate the tract and inserting catheter. Inadvertent injury to carotid artery is prevented by this measure. Only 33% responded with real time confirmation of guide wire. Guidewire confirmation can also be done by surface ultrasound i.e. transthoracic echocardiography (TTE), continuous intra-atrial electrocardiography and fluoroscopy. [3] CVC tip location confirmation is also recommended. A chest radiograph should be performed to confirm the location of the catheter tip as soon as possible. Other methods like fluoroscopy or TTE could also be used to confirm correct positioning before use.

During CVC insertion 82.88% respondent used one assistant with rest engaging two assistant. In contrast, during arterial cannulation, 42.34 % didn't take the help of any assistant. For any procedure of vascular access, it is advised to take help of assistant to improve success rate, minimize procedural time and avoid complication especially during placement of a guidewire and CVC. [3]

In our ICU, each shifts were of 6 hours duration. The mere donning of PPE, wearing it for 6 hours and doffing it is a daunting task. These difficulties are inherent to the current COVID-19 era. The various difficulties faced were impaired vision due to fogging, impaired body movement and suboptimal patient positioning, difficulty in communication, impaired hand grip/equipment handling and difficulty in sedation. Though all the problems faced cannot be eliminated, we need to anticipate them, so that we are better prepared to deal with them. Proper donning of mask and goggles can minimize the fogging along with proper ICU air circulation.

To do any procedure efficiently, one requires optimal positioning of the patients for easy maneuverability, minimize time and avoid complications. For CVC insertion in the upper body, Trendelenburg position is optimal. [12] The vessel diameter and cross-sectional area increase to great extent when compared to supine position. This holds true also for pediatric patients more than 6yrs old. [13]. In COVID-19 scenario, optimal patient positioning has become imperative. It expedites the procedure and improves the success rate. However, our survey found that in only 66.66% patients, Trendelenburg position was used for CVC insertion and in only 27.92% patient arterial line was inserted after optimal positioning. This may be due to technical problems to create such a position because of the bed dynamics and PPE restriction. This inability to make favored optimal position should encourage us towards including ultrasound as an integral part of procedure. Patient counseling prior to procedure to allay anxiety in awake patients may allow optimal position. Increased oxygen support during draping and Trendelenburg position may minimize the dyspnea associated with these maneuvers.

In our study we found that there were no complications. Reason for this could be that Firstly, most of the procedures were done by trained intensivists (83.3% of CVC and 92.79% of arterial cannulation); secondly only the immediate complications were accounted for. Long term follow up of these patients will elucidate the long term mechanical and thrombotic complications of these procedures. Ultrasound-guided access has been shown to decrease complications associated with CVC insertion and arterial cannulation. [4, 14, 15] These errors and complications following central line insertions will also result in

increased exposure of the virus to frontline healthcare workers needed for the work-up, imaging, and intervention needed to manage these complications. An arterial line should be maintained with a pressure flush system either with a pressure bag or a syringe pump to prevent clogging of blood in the monitoring line thereby showing any erroneous reading in vitals. [16] In our survey all the respondents flushed the line with pressure bag with 28.6% did an additional intermediate flush. This is important as COVID -19 patients are prone to sudden hemodynamic disturbances owing to hypercoagulable state predisposing them to systemic thrombus formation and dislodge.

Our study has a few limitations. Firstly it is a questionnaire based survey, the data of which is always under scrutiny on the issue of reliability. Secondly we have included only the immediate complications of the vascular procedures, the long term mechanical, thrombotic and infectious complications have not been addressed. We have only analyzed the responses to our set questions and have not included the number of times a single respondent have done the procedures. Our study was to bring out the experiences of the individuals while doing the procedure rather then the number of procedures done.

6. Conclusion

Central venous catheterization and arterial cannulation should only be performed in an environment that permits use of aseptic techniques. Standardized equipment should be available prior to performing these procedures. USG guided techniques should be followed during all vascular procedure to bring about maximum benefit with minimum risk. The operator must strictly adopt the "standard" maximal barrier precautions (hand hygiene, surgical mask, beret, sterile impermeable gown, sterile gloves, wide sterile drapes over the patient, appropriate sterile cover for the ultrasound probe) in addition to PPE and necessary insertion site asepsis. Each ICU should set up a mandatory checklist or protocol to ensure the safety of the care giver without compromising safety of the patient.

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