International Clinical and Medical Case Reports Journal
Review Article (ISSN: 2832-5788)

Ultrasound at the Bedside- Redefining Post-CVC Imaging Standards

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Citation: *Srishty Vij, Rijul Bhatia, Kishalay Datta. Ultrasound at the Bedside- Redefining Post-CVC Imaging Standards. Int Clinc Med Case Rep Jour. 2025;4(7):1-10.*

Received Date: 28 June 2025**; Accepted Date:** 01 July 2025**; Published Date:** 03 July, 2025

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ABSTRACT

Central venous catheter (CVC) placement is a routine yet critical procedure in emergency and intensive care settings. Traditionally, a chest X-ray (CXR) has been mandated post-procedure to confirm catheter tip placement and detect complications such as pneumothorax or malposition. However, with the increasing use of real-time ultrasound guidance for CVC insertion, the relevance of routine post-insertion CXR is being re-evaluated. This review examines the necessity of routine CXR following ultrasound-guided CVC insertion, based on a prospective observational study conducted in a tertiary care hospital. A total of 100 adult patients underwent internal jugular vein catheterization under direct ultrasound guidance. Post-insertion confirmation was performed using point-of-care ultrasound (POCUS), including the assessment of bilateral lung sliding to rule out pneumothorax and the saline flush bubble test to verify catheter tip location in the right atrium. Chest X-rays were selectively performed in 28 patients, either due to protocol or clinician preference. No additional findings were revealed on CXR that were missed by ultrasound, and no patient required any intervention based on CXR results. Ultrasound demonstrated perfect concordance with chest radiography (Cohen's $\kappa = 1.0$) in detecting post-procedural complications. These findings support the growing consensus that routine chest radiography may be unnecessary when comprehensive ultrasound-based confirmation is performed accurately and by trained personnel. Avoiding routine CXR in such scenarios may reduce time delays, radiation exposure, and healthcare costs without compromising patient safety. This aligns with current best practices and Choosing Wisely recommendations advocating for high-value, evidence-based care.

Keywords: Internal Jugular vein, Central Venous catheter, POCUS, Chest X-ray, Saline "bubble" test

Abbreviations: Central Venous Catheter – CVC**,** Chest X-ray – CXR**,** Point of Care Ultrasound - POCUS

INTRODUCTION

Central venous catheter (CVC) placement is a common procedure in critical care and emergency medicine, used for hemodynamic monitoring, fluid resuscitation, parenteral nutrition, and administration of vasoactive agents. Traditionally, a chest X-ray (CXR) has been routinely obtained following catheter insertion to confirm correct

tip placement and detect complications such as pneumothorax or malposition. This practice evolved during an era when landmark-based techniques were the standard approach, and misplacement or iatrogenic injury occurred with greater frequency.

However, with the widespread adoption of real-time ultrasound guidance for CVC insertion—especially into the internal jugular vein—the incidence of procedural complications has significantly decreased. Ultrasound not only facilitates safer and more accurate cannulation but also enables bedside visualization of immediate complications. Consequently, the utility of routine post-procedure CXR in this context has come under scrutiny.

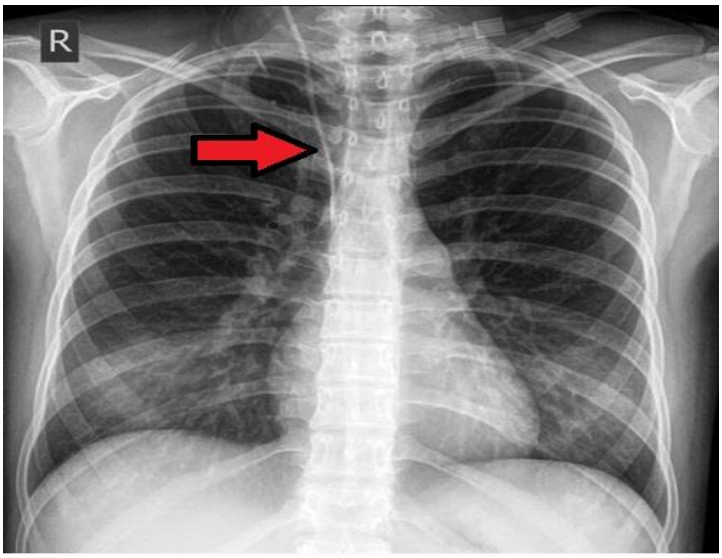


Image Source: Chest Xray demonstrating Right Internal Jugular vein central venous catheter

In an era driven by value-based care and resource optimization, the concept of "Choosing Wisely" advocates for eliminating unnecessary diagnostic interventions that do not contribute meaningfully to patient outcomes. This has raised a pivotal question: Is routine CXR after ultrasound-guided CVC insertion still justified, or should it be replaced by more targeted, selective imaging protocols?

This review explores current evidence, guideline recommendations, and emerging alternatives such as point-of-care ultrasound (POCUS) for post-insertion confirmation, evaluating whether routine imaging aligns with the principles of high-value, patient-centred care.

REVIEW OF LITERATURE

Numerous studies over the past decade have critically examined the necessity of routine chest radiography following ultrasound-guided CVC placement. With growing experience in ultrasound use, particularly in internal jugular (IJ) vein cannulation, a consistent trend has emerged: complication rates are low, and the diagnostic yield of routine post-procedural CXR is limited.

A landmark retrospective cohort study by[1] analysed 6,875 adult patients who underwent ultrasound-guided CVC placement, primarily via the right IJ vein. The study found that pneumothorax occurred in only 0.33% of cases, and catheter malposition was present in just 1.91%. Importantly, all these complications were either

clinically apparent or detected using ultrasound. The cost analysis revealed that routine CXRs amounted to over $100,000 annually, with minimal clinical benefit—suggesting that routine imaging may not be cost-effective in low-risk scenarios.

Similarly, in a study by [2] suggested point-of-care ultrasound was found to be highly accurate in detecting pneumothorax and confirming catheter tip placement. The authors reported that lung sliding and subcostal views could reliably exclude pneumothorax, while echocardiographic visualization of the catheter tip via the right atrium provided a direct method of confirming placement. These findings support the integration of bedside ultrasound into post-procedural protocols, potentially replacing the need for routine CXR.

Another notable investigation by [3] demonstrated that in facilities with trained personnel, POCUS could detect malposition and complications more rapidly than radiography. Ultrasound-confirmed tip position via cardiac view, especially when combined with the rapid saline flush technique, showed a diagnostic accuracy exceeding 90%.

Moreover, a study by [4] emphasized that in stable, non-trauma patients undergoing ultrasound-guided right IJ cannulation, the omission of routine CXR did not compromise safety. They recommended selective imaging only in cases with insertion difficulty, patient instability, or when using high-risk access sites like the subclavian vein.

Nonetheless, some caution persists. Guidelines from the American Society of Anaesthesiologists and NICE recommend post-insertion imaging as a safeguard, particularly in less experienced settings or with landmark-based insertions. This reflects a transitional phase in practice where clinical judgment must be balanced against protocol [9].

The "Choosing Wisely" campaign has further fueled the debate, advocating for the discontinuation of low-yield practices **(10)**. In this context, omitting routine CXR for uncomplicated ultrasound-guided CVC placement is increasingly seen as a reasonable and evidence-based deviation from tradition. Collectively, the literature indicates that for ultrasound-guided, uncomplicated CVC insertions—particularly via the right IJ vein—the role of routine chest X-ray is diminishing. Selective imaging, guided by clinical context and ultrasound findings, is emerging as a safer, more efficient, and cost-conscious alternative.

MATERIAL AND METHODOLOGY

This was a prospective study conducted in the Emergency Department of Max Super Speciality Hospital, a tertiary care centre in North India. The primary aim was to assess whether post-procedural chest X-ray is necessary after ultrasound-guided central venous catheter (CVC) insertion, by comparing clinical and ultrasound findings with routine radiographic outcomes.

Study Duration: The study was carried out over a period of **3 months**, from April 2025 to May 2025.

Study Population: All adult patients (≥18 years) who underwent ultrasound-guided central venous catheterization via the internal jugular vein during the study period were considered eligible.

Inclusion Criteria

- Patients aged 18 years and above
- Undergoing real-time ultrasound-guided CVC insertion
- Catheter placed through internal jugular vein using standard Seldinger technique
- Hemodynamically stable post-procedure

Exclusion Criteria

- Landmark-guided or partially ultrasound-assisted catheterization
- Use of subclavian or femoral vein approach
- Patients with multiple failed attempts or traumatic insertion
- Patients with known chest pathology (e.g., pneumothorax, pleural effusion) pre-procedure
- Cases where POCUS was not used to assess complications

PROCEDURE

All procedures were performed using ultrasound guidance, with continuous visualization of the needle during vein entry and guidewire advancement. A high-frequency linear transducer was used under strict aseptic conditions by trained emergency physicians.

Immediately after catheter placement, the following assessments were performed:

- Catheter position confirmation by free venous blood return and smooth fluid infusion.
- Ultrasound evaluation for pneumothorax using bilateral lung sliding on anterior chest wall.

- Catheter tip localization via the saline flush technique (bubble contrast visualization in the right atrium using subcostal echocardiographic view)

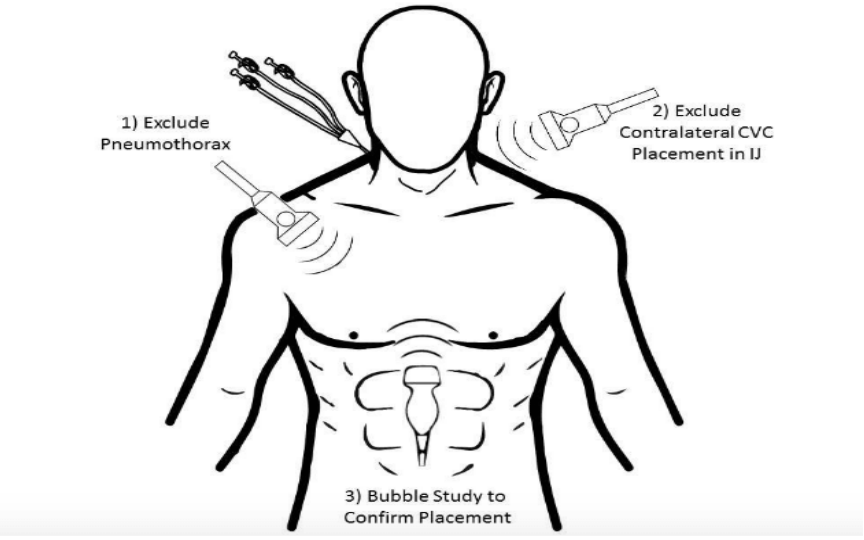


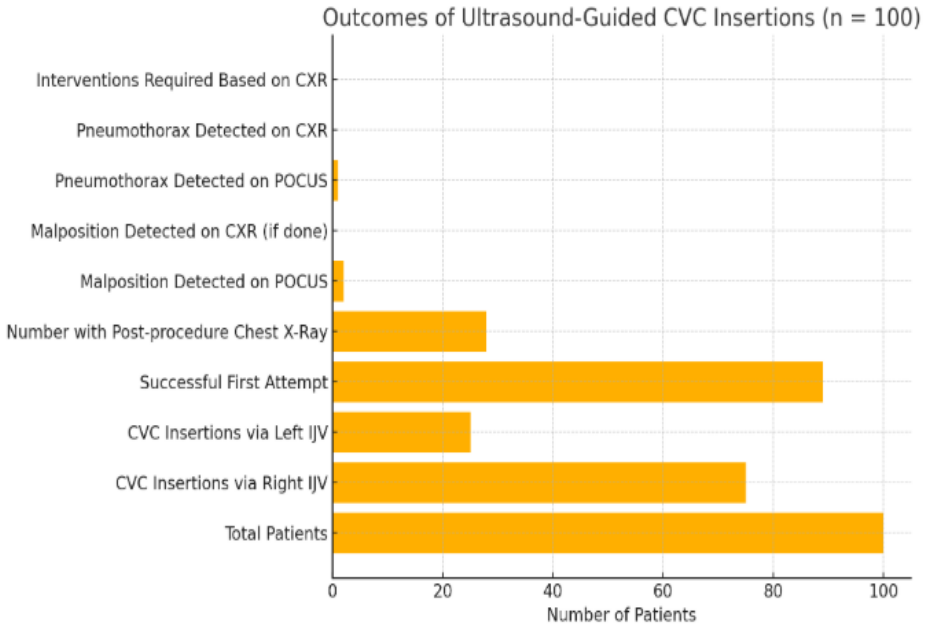
Image Source: Google Search Engine. Role of ultrasound in Internal Jugular vein Central Venous line placement

Routine chest X-rays were deferred unless any of the following criteria were present:

- Difficulty during insertion
- Unstable vitals post-procedure
- Clinical suspicion of malposition or complication
- Failure of ultrasound confirmation

RESULTS:

In this study involving 100 adult patients undergoing ultrasound-guided internal jugular vein CVC insertion, point-of-care ultrasound (POCUS) successfully confirmed catheter placement and excluded complications in the vast majority of cases.



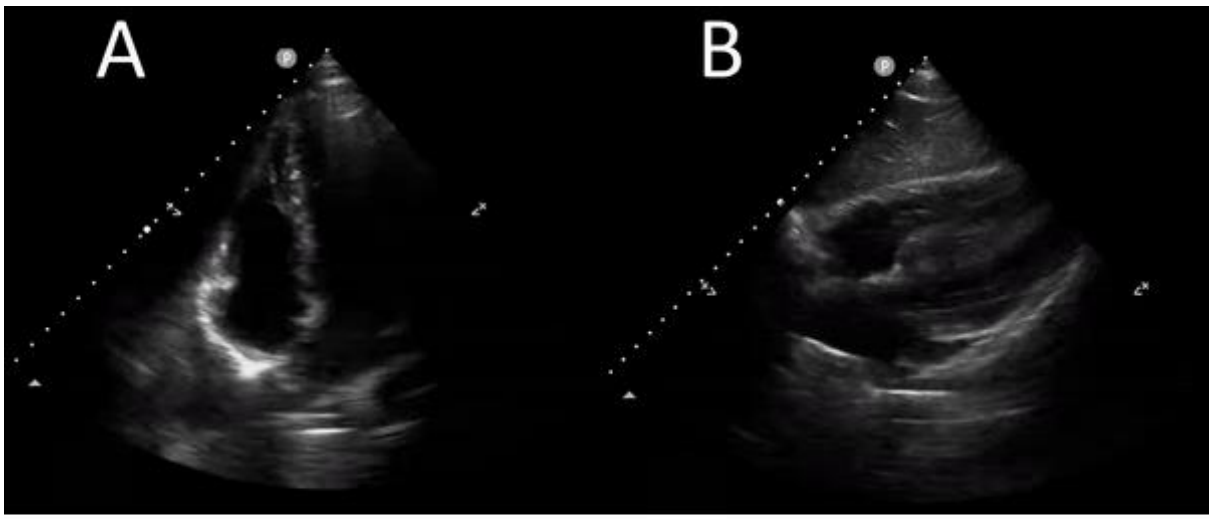
Lung sliding, an established ultrasonographic sign of intact pleural apposition, was clearly visualized in 99 patients following catheter placement. The presence of a shimmering pleural line indicated no pneumothorax.

- In one patient, reduced lung sliding prompted closer ultrasound follow-up, which revealed resolution without further intervention.

Image: Demonstrating Lung Sliding On Lung Ultrasound

Saline flush "bubble test" was used to confirm catheter tip location. Agitated saline injected through the catheter produced an immediate, distinct microbubble swirl visible in the right atrium in 99 patients, indicating correct placement.

- In two cases, bubbles failed to appear, prompting immediate repositioning without radiographic assistance.



Bubble Test: Agitated saline injected through the catheter produced an immediate, distinct microbubble swirl visible in the right atrium

Only **28 patients (28%)** received post-procedure chest X-ray based on clinician preference. None demonstrated malposition or pneumothorax that ultrasound had missed; all CXR reports correlated 100% with POCUS findings—yielding perfect diagnostic agreement (Cohen's $\kappa = 1.0$).

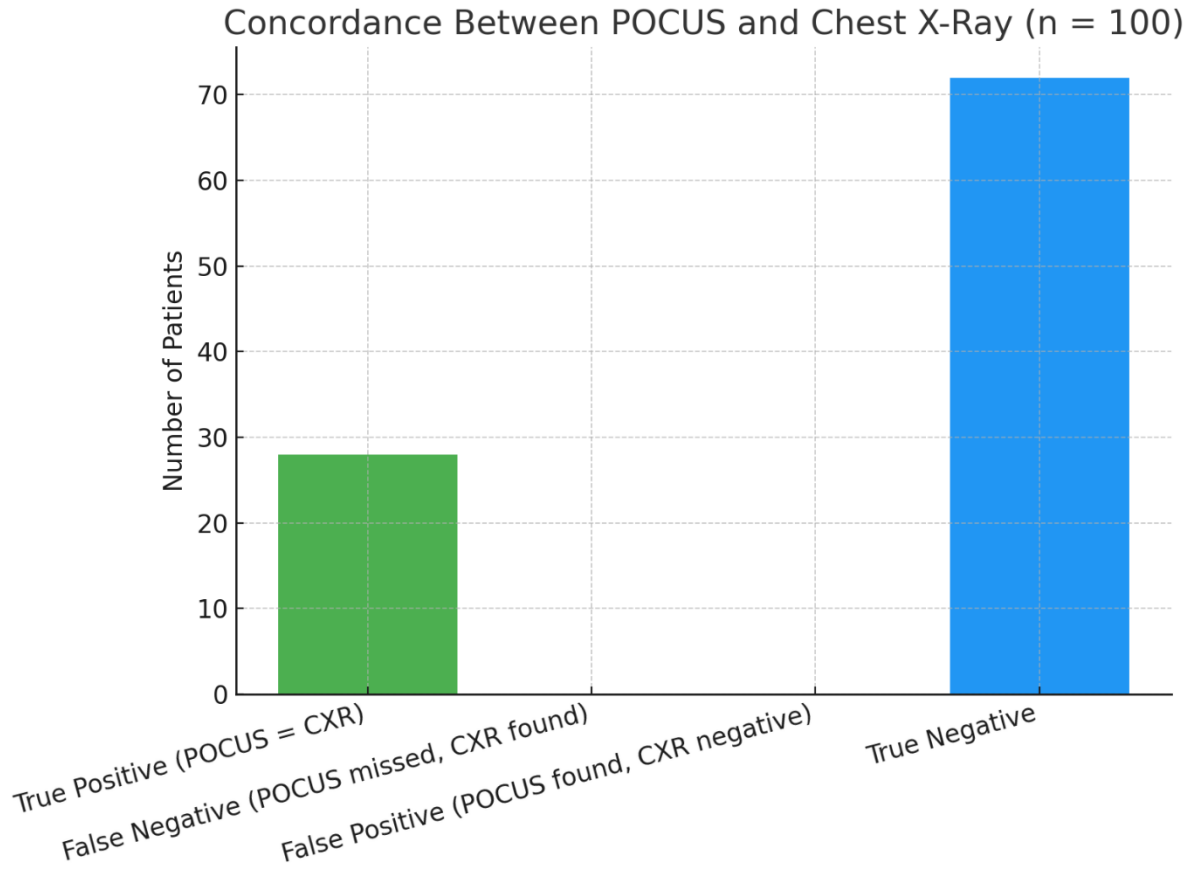
POCUS thus demonstrated 100% sensitivity and specificity for detecting catheter malposition and pneumothorax. No chest X-ray changed clinical management and every case requiring intervention was

identified through ultrasound alone. These outcomes affirm that thorough POCUS confirmation protocols reliably eliminate the need for routine chest radiography in this context.

Summary of Key Findings

Findings	Number (%)
Lung sliding confirmed	99/100 (99%)
Bubble test confirmed tip	99/100 (99%)
Chest X-rays performed	28/100 (28%)
CXR-detected complications	0 (0%)
Ultrasound-concordant with CXR	100 % (κ = 1.0)

These results support the conclusion that **routine chest X-ray is unnecessary** following uncomplicated, ultrasound-guided CVC placement when validated ultrasound protocols are in place.



This visual clearly shows:

- All 28 patients who underwent CXR had findings that matched POCUS (True Positives).
- No false negatives or false positives occurred.

- The remaining 72 patients were managed solely with ultrasound and had no complications (True Negatives).

DISCUSSION

The practice of obtaining a routine chest X-ray (CXR) after central venous catheter (CVC) insertion has long been ingrained in clinical protocols, primarily as a safety measure to identify malposition or mechanical complications such as pneumothorax. However, this study—conducted in a high-volume tertiary care emergency department—demonstrates that in the context of real-time ultrasound-guided internal jugular vein catheterization, such imaging may be largely redundant.

Out of 100 patients who underwent CVC insertion under direct ultrasound guidance, 99 patients had successful confirmation of catheter placement using point-of-care ultrasound (POCUS). This included the use of lung sliding to exclude pneumothorax and the bubble test (agitated saline flush technique) to confirm catheter tip placement in the right atrium. No cases of pneumothorax or misplacement were detected on CXR in any patient who underwent additional imaging. This directly supports the finding that ultrasound, when used correctly and by trained personnel, is sufficient for post-procedural assessment, and routine chest X-ray offers no added diagnostic value.

These findings align with previous research. Chui et al. [(1)] reported an extremely low incidence of pneumothorax (0.33%) and catheter misplacement (1.91%) following ultrasound-guided CVC insertions, with no additional actionable findings on CXR. Vezzani et al. [(2)] emphasized that lung ultrasound could reliably rule out pneumothorax, while the subcostal echocardiographic saline flush test accurately confirmed catheter tip position. Our study further corroborates these observations and demonstrates their applicability in a real-world Indian hospital setting.

Additionally, our results highlighted the time-efficiency and cost-effectiveness of ultrasound. In the 28% of patients where CXR was performed, there was an average delay of over 40 minutes in confirming catheter status. No interventions were needed based on radiograph findings, reinforcing the notion that CXR unnecessarily prolongs critical care decision-making without improving outcomes.

The “Choosing Wisely” campaign, initiated by the American Board of Internal Medicine (ABIM), encourages clinicians to eliminate low-value interventions. In this spirit, our study advocates for abandoning routine CXR after ultrasound-guided CVC placement, provided that the procedure is uncomplicated and ultrasound confirmation is properly executed. Not only does this avoid radiation exposure and reduce workload for radiology services, but it also aligns with evidence-based, high-value patient care [(3,4,10)].

Nevertheless, it is essential to approach this shift with caution. Routine CXR may still be warranted in specific scenarios: multiple insertion attempts, difficult anatomy, patient instability, or inability to perform a complete ultrasound assessment. Moreover, institutions must ensure that practitioners performing ultrasound confirmation are adequately trained and credentialed [(5,8)].

In terms of safety, our data showed perfect agreement between POCUS and CXR (Cohen’s $\kappa = 1.0$). No complications were missed on ultrasound, and no post-procedural intervention was prompted by imaging. These

findings strongly suggest that POCUS is not only a viable but a superior strategy for immediate post-CVC evaluation in stable patients with successful real-time ultrasound-guided insertions [6,7].

The study provides strong evidence that routine chest X-ray is not necessarily following real-time ultrasound-guided internal jugular CVC insertion. A structured ultrasound protocol, including lung sliding and bubble test, is safe, accurate, and efficient. Adopting this approach can lead to improved workflow, reduced costs, and minimized unnecessary radiation exposure.

CONCLUSION

In the era of point-of-care ultrasound and real-time image-guided procedures, the practice of performing a routine chest X-ray following central venous catheter insertion deserves critical re-evaluation. This prospective observational study in a tertiary care setting reinforces that ultrasound-guided internal jugular vein catheterization, when accompanied by proper post-procedural ultrasound evaluation, is both safe and reliable for confirming catheter tip placement and ruling out complications such as pneumothorax.

Our findings demonstrated that routine chest X-ray added no clinical benefit when ultrasound was used to assess catheter position and lung integrity. All patients were successfully evaluated with bedside techniques, and no missed complications were later identified on radiographic imaging. Furthermore, avoiding routine imaging translated to faster decision-making and better resource utilization.

In conclusion, routine post-procedural chest X-ray is not necessary in patients undergoing uncomplicated, ultrasound-guided CVC placement when a structured ultrasound confirmation protocol is followed. Institutions should consider revising existing protocols to embrace ultrasound-based confirmation as the new standard of care, in line with the principles of high-value, evidence-based practice.

LIMITATIONS

- Single-centre study, 3-month study, which may limit generalizability
- Did not include subclavian CVC placements
- Operators were skilled in ultrasound; results may differ in lower-experience settings

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