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Enhanced-view totally extraperitoneal access for repair of ventral hernias: Advantages and liabilities

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ABSTRACT

The concept of enhanced-view totally extraperitoneal (eTEP) access was developed while exploring ways to facilitate the TEP approach for inguinal hernia repair. Surgeons soon noticed that the surgical space was ideal for repair of other abdominal hernias. The ''crossover'' maneuver, designed as a technique to cross from one retrorectus space to the other, permitted application of eTEP access to most hernias. eTEP access has the general advantage of working in the extraperitoneal space and the specific advantage of hernia repair allowing implementation of the modern principles of ventral hernia reconstruction and providing flexibility to address different types of hernias in different locations. The technique requires formal training and has inherent complications and limitations. The remarkable widespread acceptance and encouraging early results of this complex technique emphasize the responsibilities of proper training, judicious use, and evaluation of our own and others' results.

Acceso totalmente extraperitoneal de vista extendida para la reparación de hernias ventrales: ventajas y desventajas

Palabras clave:
Vista extendida
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Retromuscular

RESUMEN

El acceso totalmente extraperitoneal de vista extendida (eTEP, por sus siglas en inglés) fue concebido mientras se exploraban alternativas para facilitar la técnica TEP para la reparación de hernias inguinales. El gran espacio creado por un acceso retromuscular más proximal, y otras ventajas como la flexibilidad en la colocación de los trócares y una mejor ergonomía hicieron evidente su potencial para la reparación de otras hernias de la pared. La maniobra del crossover, que permite el paso de un espacio *retrorectus* al contralateral, permitió la utilización del acceso eTEP para la reparación de la mayoría de las hernias de la pared abdominal. El acceso eTEP posee las ventajas generales de trabajar en el espacio extraperitoneal y las ventajas específicas inherentes a la reparación de hernias ventrales, en especial la posibilidad de implementar los principios modernos de la reconstrucción de la pared abdominal y de reparar hernias en diferentes localizaciones utilizando el mismo plano quirúrgico. La técnica requiere entrenamiento formal y posee limitaciones y el

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potencial de complicaciones inherentes. La enorme acogida de esta técnica compleja y los buenos resultados tempranos hace necesario enfatizar en la necesidad de un entrenamiento formal, de un uso ponderado de la técnica y una evaluación de nuestros propios resultados y los de otros grupos quirúrgicos.

The concept of enhanced-view totally extraperitoneal (eTEP) access

Like many other advancements in minimally invasive surgery, the concept of enhanced-view totally extraperitoneal (eTEP) access was developed outside of traditional surgical academic centers. In 2009, while trying to find ways to facilitate the TEP approach for inguinal hernia repair mainly for teaching purposes, we observed that entering the retrorectus space from afar the hernia site overcame most of the drawbacks of the traditional TEP approach (namely the limited surgical field, constrained port setup, low tolerance to accidental pneumoperitoneum, poor ergonomics, and difficulty teaching and learning the technique). We published the results of a series of inguinal hernia repairs, many of them in complex cases, in 2011.[1–3] We soon noticed that the surgical space was ideal for repair of other abdominal hernias. We published reports on eTEP repair of Spigelian, M5, and lumbar (L4) hernias in early 2015.[4] In September 2015, Belyansky[5] reported the ''crossover'' maneuver as a way to cross from one retrorectus space to the other. This pioneering contribution revolutionized the repair of ventral, incisional, and lumbar hernias. An explosion of publications from many continents followed (including more than 40 publications in the last three years).

More than simply a technique, we consider the eTEP approach a set of maneuvers to access and develop the extraperitoneal space for hernia repair and other procedures. These maneuvers include remote minimally invasive retromuscular access to the hernia location, the creation of a large extraperitoneal surgical space, a flexible port setup adaptable to many circumstances and body habitus, and division of the natural boundaries of the extraperitoneal space when necessary.

The present report focuses on the advantages and liabilities of eTEP access for ventral hernia repair.

eTEP access

General advantages

- Working in the extraperitoneal space has various general advantages over intraperitoneal approaches, such as a lower incidence of ileus, lower risk of bowel injury, lower risk of postoperative intraperitoneal adhesions and their consequences, and fewer physiologic disturbances.
- The eTEP approach provides very flexible access to the extraperitoneal space. The ports can be placed in many locations: 1 – the upper abdomen (preferred in the laparoscopic approach), 2 – the lateral abdomen (preferred in the robotic-assisted approach), 3 – the inferior abdomen (preferred for subxiphoid hernias, and – using a limited eTEP dissection – for mesh-requiring umbilical hernias), 4 – out-of-the-cavity or precostal region (our preferred approach for most laparoscopic eTEP access repairs), and 5 – directly lateral to the semilunar line (for the repair of L4 hernias and to perform a triple neurectomy). Fig. 1 describes various port set up used to address hernias in different locations.
- The eTEP approach can be used to develop a potential extraperitoneal space from the pelvic area to the central tendon of the diaphragm and from the psoas, iliacus, and quadratus lumborum on one side of the abdomen to those on the other.[6]
- The technique can be consistently taught and standardized by practicing with a cadaver model and working closely with an experienced mentor, as demonstrated in the American Hernia Society's hands-on courses.

eTEP access

Specific advantages

1. eTEP access permits implementation of the modern principles of ventral hernia reconstruction,[7] including the following.
   - eTEP access allows primary closure of hernia defects and reconstruction of the linea alba. Primary closure of defects and re-establishment of the linea alba under physiologic tension are the mainstays of open repair. They have recently been considered essential components of minimally invasive abdominal wall reconstruction.[7] Studies have corroborated substandard results after bridged repairs with high rates of surgical-site events, recurrences, bulging, and patient dissatisfaction.[8,9]
   - Placement of meshes in the retromuscular plane makes sense from a physics viewpoint; it facilitates mesh integration, lessens the need for mechanical fixation, and diminishes cost by using standard, non-protected meshes. A Danish registry study concluded that the sublay positioning of meshes resulted in the lowest risk of long-term reoperation when compared with the intraperitoneal and onlay positions.[10] The RICH study[11] and COBRA study[12] also demonstrated a significant reduction in recurrence with retromuscular positioning of meshes than with intraperitoneal placement.
   - eTEP access allows for mesh reinforcement of the visceral sac. Wide prosthetic reinforcement of the visceral sac, first described by Stoppa as a highly effective repair technique for complex inguinal hernias, has been successfully applied to repair ventral hernias.

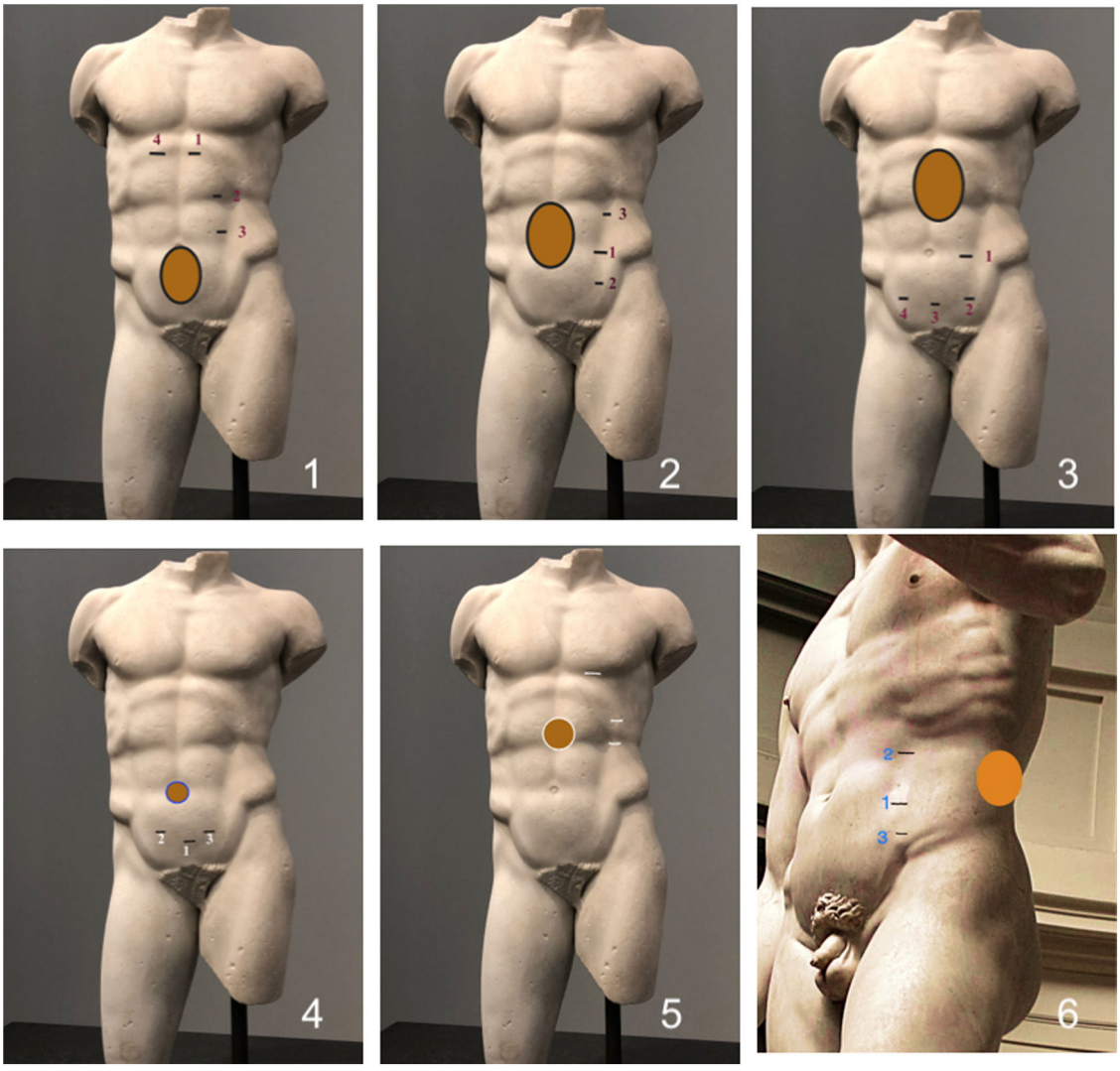

Fig. 1 – Possible eTEP port setups. 1 – the upper approach is the most often used laparoscopically for midabdominal, inferior, and some lateral hernias. 2 – the lateral approach is favored by robotic surgeons for most hernias. 3 – the lower approach is used for subxiphoid and other upper hernias. It is the least resorted to of the three. 4 – the precostal approach is favored by our group for almost all ventral hernia repairs. 5 – Mnouskin eTEP limited approach for umbilical hernias that require mesh with or without associated inguinal hernias and, 6 – directly-lateral-to-the-semilunar-line approach for lumbar (L4) hernias.

- The eTEP approach offers unique extraperitoneal and minimally invasive access.

2. The flexibility of eTEP access allows for straightforward repair of common hernias and hernias in difficult subcostal, subxiphoid, pelvic, and lateral locations using adequate prosthetic coverage in one surgical plane.
3. eTEP access allows for the simultaneous repair of inguinal, ventral, incisional, central, and lateral hernias using the same surgical space.
4. A hybrid technique can be implemented in complex cases. This may be a helpful adjunct to remove dystrophic skin, remove old meshes, and facilitate midline closure and placement of meshes.
5. A restricted eTEP approach can be implemented to repair umbilical hernias that require prosthetic reinforcement with or without concomitant inguinal hernias.[13]

The above advantages have translated into a cost-contained, reproducible, safe, and effective procedure with improved quality-of-life measurements, including less pain, good mobility, and a short hospitalization stay. The recent prolific literature on eTEP access for ventral hernias seems to support these claims.

Studies evaluating the early experience of eTEP access for ventral hernia repair

- The first publication on eTEP Rives repair and eTEP-transversus abdominis release (TAR) by Belyansky et al.[14] was a multicenter, multinational study involving 79 patients with a mean defect area of 132 cm^2; mean defect width of 6.2 cm and 11.1 cm in the eTEP Rives and eTEP TAR groups, respectively; mean body mass index (BMI) of 31 kg/m^2;

previous hernia repair in 34% of the patients; and 50% of the total group requiring TAR. The authors demonstrated that the procedure was reproducible, safe, and effective. The morbidity was low, and only one recurrence was detected 1 year after the surgery. The length of stay was 1.8 days (1 day for eTEP Rives-only patients), and the procedure length was 218 min. The authors described a notable improvement in pain and mobility at 1 and 6 months after surgery compared with the preoperative data using the Carolinas Comfort Scale. The authors mentioned that quality-of-life issues compare favorably with the findings reported by Colavita et al., who evaluated pain and motility after traditional laparoscopic ventral hernia repair.[14]

- Quezada et al.[15] described their initial mid-term results using the eTEP Rives, and eTEP TAR approaches to repair ventral hernia with associated diastasis recti and associated lateral and inguinal hernias in 66 patients. They reported a low recurrence rate (1.5%) and surgical site events in 15% of patients, with four (6%) requiring surgical reintervention and one needing removal of an infected mesh. The mean length of stay was two days.
- Radu and Lica[16] described their initial personal experience with eTEP access for ventral and incisional hernias with a few associated inguinal hernias in 60 patients. They reported no recurrences during 15 months of follow-up, low pain levels, and significant improvement in quality-of-life issues. Four conversions were required: two for respiratory problems and two for technical reasons (fibrosis and bowel adhesions to a mesh). One early readmission for an internal hernia was due to posterior layer failure that required reoperation. The authors described a semilunar line disruption caused by balloon overinflation at the time of the creation of the retromuscular space.
- Other authors, including Baig and Priya,[17] Mitura et al.,[18] Taşdelen,[19] Burdakov et al.,[20] and Ngo et al.,[21] have reported similar early experiences.

Studies evaluating the early experience of eTEP for lateral hernias

- Hérnandez-Villafranca et al.[22] described the results of 34 eTEP access repairs for lateral hernias, most of them L3 W2 hernias. The hospital stay was a mean of 1 day, with 50% of the patients managed as day care surgery. Morbidity was low. One recurrence was detected at 13.5 months follow-up.
- A series of 33 eTEP access repairs for lateral hernias in larger and more complex cases were described by Khetan et al.,[23] reporting very low morbidity and recurrence rate and quality of life improvement during a follow-up up to 24 months.
- The robotic papers section discusses other studies on eTEP access for lateral hernias using robotic assistance.

Studies comparing eTEP access with intraperitoneal onlay mesh repair (IPOM) and other techniques in the repair of ventral hernias

- Kumar et al.[24] published a prospective randomized study of 92 patients comparing eTEP access with IPOM + hernia defect closure (IPOM plus) for ventral hernia repair. The groups were statistically comparable, and the mean defect width was 4 cm in both groups. The eTEP group had a longer surgical time (107 vs. 75 min) but significantly less pain, less need for analgesics, and a shorter length of hospital stay than the IPOM plus group. Two posterior layer disruptions occurred in the eTEP group and accounted for the only recurrences.
- Jain et al.[25] published a randomized controlled trial comparing eTEP access with classical IPOM to repair ventral and incisional hernias in 120 patients. The mean defect width in the series ranged from 2 to 5 cm. Pain at rest and during regular activity was significantly less severe in the eTEP group and only became similar to that in the IPOM group at 3 and 6 months, respectively. The patients in the eTEP group returned to daily activities earlier than those in the IPOM group. The quality-of-life issues measured by various scales were significantly better in the eTEP group, whereas the procedure cost was considerably greater in the IPOM group.
- In a retrospective comparison between eTEP Rives repair and the transabdominal retromuscular technique, Rege et al.[26] found no differences in morbidity or recurrence. However, they observed significantly less pain in the eTEP Rives group.
- Bui et al.[27] compared eTEP access with IPOM to repair ventral hernias in two equivalent groups. The study showed that the laparoscopic eTEP Rives approach was safe and effective compared with traditional laparoscopic IPOM. The patients undergoing eTEP Rives repair had a significantly reduced need for additional analgesic treatment and a shorter length of hospital stay. The procedure took longer to perform in the eTEP than IPOM group.
- In a study comparing laparoscopic ventral hernia repair with eTEP access in two very similar groups, Bellido Luque et al.[28] found that eTEP access produced significantly less postoperative pain, better functional recovery, and better cosmesis than did IPOM plus without differences in intraoperative or postoperative complications (except for a more significant seroma rate in the IPOM plus group). There was no difference in the recurrence rate during follow-up between the two groups. Paralytic ileus was only observed in the IPOM plus group (12.6%). eTEP access required a longer operative time.
- Finally, Li et al.[29] performed a meta-analysis of studies comparing eTEP access with IPOM plus for ventral hernia repair in 433 cases. The authors concluded that although the eTEP approach took longer to perform, it was less painful, had a faster recovery time, and had a shorter hospital stay when compared with IPOM.

Studies reporting the use of robotic assistance

- Belyansky et al.[30] were the first to use a robotic platform for eTEP Rives (eRS) and eTEP TAR (eTAR) repair of ventral, incisional, and lumbar hernias. They performed these procedures in 37 patients with a mean BMI of 35.5 kg/m^2. The authors observed that some of the technical and ergonomic challenges encountered in laparoscopic eTEP cases were resolved with the addition of the robotic platform. A single dock approach was used in all cases. The mean length of hospital stay was 0.5 days. Morbidities

were limited to seroma formations that were managed by radiologic intervention. The follow-up period was short. Patients with a higher BMI, recurrent defects, and reoperative areas were more likely to be selected for robotic eRS and eTAR than laparoscopic eTEP.

- Lu et al.[31] compared the outcomes of laparoscopic eTEP access Rives repair with robotic-assisted eTEP Rives repair in 206 patients (120 laparoscopic and 86 robotic) from 2015 to 2018. Many variables were comparable, but the robotic group had a higher BMI, American Society of Anesthesiologists score, and wider defect width (7.1 vs. 5.5 cm). The morbidity rate was higher in the laparoscopic group because of chronic seroma formation, but it was still low in both groups. Both groups' quality-of-life issues measured by the Carolinas Comfort Scale were excellent. The length of stay, length of drain placement, reoperation rate, and recurrence rate were similar in both groups. The operative time and hospitalization cost were greater in the robotic group. This may be explained by the fact that patients with morbid obesity and those with more complex abdominal wall defects were more likely to undergo the robotic eTEP Rives technique.
- In a study on the learning curve of eTEP Rives procedures with robotic assistance, Lima et al.[32] found a significant decrease in the operative time after 38 cases.
- In a study on the learning curve of robotic Rives-Stoppa ventral hernia repair, Kudsi et al.[33] noted a progressive reduction in the skin-to-skin operative time and complication rate in a cohort of 81 patients, with eTEP access repairs taking less time to complete than transabdominal Rives repairs.
- Moore et al.[34] reported that novice participants could perform surgical tasks more quickly and accurately using the robotic platform than the laparoscopic approach. They showed greater transferability of surgical skills to more complex tasks.
- Kudsi and Gokcal[35] performed a feasibility study of robotic eTEP access for lateral hernias in a series of 52 cases with good results.

Studies on performing more limited eTEP dissection for ventral hernia repair

- Mnouskin et al.[13] recently described an eTEP inferior access technique with tailored retromuscular dissection for small to mid-sized umbilical hernia repairs with or without inguinal hernias, thus addressing the concern of eTEP access being excessive for smaller cases. The authors described the details of this technique and reported excellent results. This strategy may well become state of the art for repairing umbilical hernias that require mesh reinforcement with or without associated inguinal hernia repair.

eTEP access liabilities

- The extraperitoneal space is unfamiliar to most surgeons. Navigating this space can be disconcerting. Profound knowledge of the extraperitoneal anatomy and its vascular and neural structures is a prerequisite to attempting eTEP repair of ventral and incisional hernias.
- eTEP access requires advanced minimally invasive surgical skills.
- eTEP access is a difficult procedure that requires formal training. Robotic assistance facilitates the procedure.[28]
- Early accidental pneumoperitoneum may compromise the space and the procedure.
- Previous retromuscular procedures make the procedure difficult, particularly if meshes were used.
- eTEP access may not be a cosmetically appealing technique for small central hernias combined with diastasis for patients concerned with cosmesis.
- eTEP access is not indicated in patients deemed poor candidates for a minimally invasive procedure, e.g., patients with low physiologic reserve, previous or recent infections, active fistulas, multiple previous repairs with meshes, loss of domain, substantial defects (>20 cm), or requirement for extensive skin and subcutaneous resection.
- eTEP access has inherent complications such as the development of an intraparietal hernia due to posterior layer disruption, development of a linea alba hernia due to straying anteriorly during crossover, development of large hematomas and seromas on account of the extensive surgical space, and linea semilunaris disruption during balloon dissection or the performance of TAR. Although these complications were reported in low numbers in the studies cited above, there is a genuine concern among the pioneers of eTEP access that widespread use of the technique may increase the number of complications.
- Some surgeons are concerned that changes in the shape of the abdomen may occur because of the lack of posterior

Table 1 – eTEP access for the repair of ventral hernias.

Advantages	Liabilities
• Minimally invasive and extraperitoneal • Flexible access and extensive dissection of the potential extraperitoneal space • Trainable and standardizable • **Permits implementation of the modern principles of AWR** • Allows for repair of ventral hernias in all locations and simultaneous repair of ventral and inguinal hernias in the same plane • Permit a hybrid strategy • Allows for limited extraperitoneal dissection for umbilical hernias with o without concomitant inguinal hernias • Well evaluated in the current literature	• Space is unfamiliar to most surgeons. • Requires formal training and advanced minimally invasive skills • Early accidental pneumoperitoneum, previous retromuscular procedures, and old meshes may compromise the procedure • Contraindicated in patients who are poor candidates of minimally invasive procedures • **It has inherent complications** such as internal hernias, linea alba hernias, linea semilunaris disruption, and large fluid collections. • It may not be cosmetically appealing for small hernias with diastasis. Also, changes in the abdomen's shape may ensue in some patients because of lack of PRS closure.

sheath closure in most eTEP Rives procedures. Studies are underway to evaluate this issue. Some surgeons are inclined to close this layer in slim patients with cosmetic concerns, preferably using robotic assistance.

- The need to close the posterior layer under physiologic tension may lead to TAR overuse. However, partial unilateral TAR is an acceptable adjunct to preventing closure of the posterior layer under undue tension. Other strategies to ensure posterior layer continuity and mesh isolation from intraperitoneal contents are careful reductions and use of hernia sacs to assist in posterior closure, suturing the omentum to the defect in the posterior layer, and use of protected meshes.

Table 1 summarizes the advantages and liabilities of the eTEP access for hernia repair.

Technical aspects of eTEP access

A comprehensive review of the technical aspects of eTEP access for ventral hernia repair is beyond the scope of this article. Many techniques that facilitate laparoscopic and robotic eTEP access and prevent its inherent complications are described in the literature.[36] A list of suggestions to avoid posterior layer disruption has already been given. Large hematomas and seromas can be prevented by ensuring a careful technique and hemostasis, retrieving the trocars under direct vision (port sites can be a source of brisk bleeding in the immediate postoperative period), and ensuring judicious use of drains. Linea alba hernias are avoided by optimizing the crossover. The crossover is initiated by dividing the medial aspect of the ipsilateral posterior rectus sheath. The medial limit of the retrorectus space is dissected free of adhesions. The division of the medial aspect of the posterior rectus sheath is undertaken 0.5–1.0 cm lateral to the linea alba. It is important to stay superficial to the falciform ligament and immediately posterior to the linea alba, which still has undisturbed contributions from the anterior rectus sheath. Staying in the proper plane prevents inadvertent pneumoperitoneum (caused by straying posteriorly) and damage to the linea alba (caused by straying anteriorly). Using balloons at low pressure, using alternatives to balloon dissection to create the space (such as the Optiview trocar and blunt dissection), and performing out-of-the-cavity blunt access and dissection prevent disruption of both the linea semilunaris and blood vessels.

The development of the extraperitoneal space in different locations dividing its natural boundaries is shown in an edited video.[37]

Afterword

eTEP access is a unique extraperitoneal and minimally invasive strategy to repair abdominal hernias, setting the modern principles of abdominal wall reconstruction in motion. The widespread acceptance and encouraging early results of this complex technique emphasize the responsibilities of proper training, judicious use, and evaluation of our and others' results.

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Conflict of interest

None.

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