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Mitigation of the Consequences of Seroma Formation in Open Ventral Hernia Repair Using ECM Powder

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Abstract

Seroma formation after surgical procedures is a common postoperative complication observed in a variety of surgeries, including breast surgery, abdominal surgery, hernia repair, and plastic surgery. The development of seroma in the context of open ventral hernia repair, especially in the high-risk categories, has been shown to contribute to persistent morbidity and jeopardize the integrity of the repair altogether. Thus, prevention and mitigation of the negative consequences of seroma must be prospectively evaluated to ensure optimal outcomes when undertaking ventral hernia repair. The incidence of seroma formation in patients undergoing ventral hernia repair is variable and reported at rates ranging from 0.5–78% after laparoscopic repair, and 30–50% after open repair. With post surgical seroma treatment remaining elusive, surgical drains, pressure dressings, and negative pressure wound therapy are just a few of the therapies utilized by surgeons in an attempt to prevent seroma formation with mixed results. Here we look at the benefits of incorporating a Multi-Tissue Platform (MTP) Wound Powder during the closure of complex open ventral hernia repairs. Our early experience using XCelliStem wound powder has revealed a promising trend, as we have seen a reduction in seroma and seroma-related complications from 49% to 16%. In conclusion, we recommend the consideration of a MTP to be included in the closure of complex ventral hernia repairs, as well as other operations at high risk for seroma formation.

Keywords

ECM, Multi-Tissue Platform, Seroma, Ventral Hernia Repair

INTRODUCTION

Seroma formation is a common complication following a variety of surgeries including ventral hernia repair. By definition, a seroma is an abnormal collection of serous fluid containing plasma and lymphatic fluid. The etiology of seroma formation remains unclear but is most commonly thought to be secondary to the disruption of the lymphatic and vascular drainage system through extensive soft tissue dissection, leading to the creation of an anatomic dead space.[1][2] Seromas can range in severity from subclinical without measurable consequences to severe, requiring surgical intervention to address deep infections, recurrence or rejection of an implant such as mesh.[3] Current management strategies vary and are dependent on the severity of the seroma. Smaller, less complicated seromas can be managed expectantly, while larger seromas may require aspiration and drainage, or reoperation. Post-operative seromas can lead to hernia recurrence through fascial degradation.

Ventral hernias can range from a simple subcentimeter fat-containing hernia to exceedingly complex defects requiring extensive reconstruction. This variability led to the development of a staging system by Petro et al,[4] stratifying hernias as stage I, II or III based on size and presence of contamination. The development of a seroma in the context of open ventral hernia repair, particularly in stage II & III, has been shown to contribute to persistent morbidity and jeopardize the integrity of the repair altogether.[4] Incidence rates of seroma formation in patients undergoing ventral hernia repair is variable and reported to range between 0.5–78% after laparoscopic repair, and 30–50% for open repairs.[5]

Currently, the prevention of seroma formation is one of the best management strategies and focuses on minimizing dead space, promoting tissue adherence, and reducing inflammation and the exudation of fluids. This can involve surgical techniques like meticulous tissue dissection, minimizing undermining, quilting sutures, or drainage systems such as surgical drains and negative pressure wound vac therapy. External compression dressings and surgical sealants have also been employed in an effort to encourage tissue adherence and minimize seroma formation however, there is a lack of evidence to support one method as superior.[6]

Extracellular matrices (ECM) have recently become more popular in reconstructive surgery and wound healing. ECMs are derived from decellularized tissue and provide a scaffold material initially thought to provide solely a structural component for tissue ingrowth, they also contain functional molecules such as collagen, elastin, laminin, fibronectin, sGAG, lipids and growth factors. ECMs have been developed from a variety of donor tissues such as urinary bladder, small intestinal submucosa, and dermis.[7] In addition to providing a scaffold, ECMs have been shown to create a microenvironment optimal for promoting tissue remodeling. Host response to the ECM scaffold begins within hours of

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placement of the product in an active wound, initially with invasion by mononuclear cells, facilitating the complex host response and constructive remodeling.[8][9]

Advancements in regenerative medicine have led to the development of ECMs as Multi-Tissue Platforms (MTPs), utilizing more than one donor tissue to create a more optimal scaffolding matrix and the amalgamation of biomolecules and growth factors. MTPs have been shown to accelerate wound healing, promote the body's inflammatory response, accelerate wound healing and have been indicated for use in infected fields.[10][11][12] MTPs have been described to promote healing in several notoriously difficult wounds such as chronic soft tissue defects, pilonidal sinus disease, and infected wounds.[13]

In the setting of complex abdominal wall reconstruction for open ventral hernia repair, it is widely acknowledged that seroma formation can have devastating effects. With the previously described benefits of ECMs, we looked at the benefit of incorporating a MTP wound powder during the closure of ventral hernia repairs undergoing abdominal wall reconstruction. This paper discusses the utility of using MTP ECMs for seroma prevention and mitigation.

MATERIALS AND METHODS

Using a single-center retrospective model, our study evaluated all patients from a single surgeon with stage III ventral hernias that underwent open ventral hernia repair requiring complex abdominal wall reconstruction for closure. In an effort to stem the postoperative consequences of seroma in these patients, a practice change was made to incorporate a MTP ECM (XCelliStem Wound Powder, RTT) into the closure of open ventral hernia repairs with abdominal wall reconstruction in an effort to prophylactically minimize or prevent seroma formation. A total of 97 contiguous patients were identified who had undergone open ventral hernia repair at our institution by a single surgeon, 72 of which did not incorporate XCelliStem and 25 who incorporated XCelliStem during closure.

Only type III ventral hernias that necessitated an open repair with abdominal wall reconstruction were included in this study due to their increased risk of complications with a reported 42% hernia-specific complication rate and 26% recurrence rate.[4]

XCelliStem was placed along the anterior abdominal wall fascia beneath the adipocutaneous layer with judicious use of surgical drains (Figure 1). Surgical drains were placed similarly in all patients throughout the multi-layer closure of the abdominal wall reconstruction. Drains were then removed in our clinic once their outputs had been less than 30cc/day for greater than one week.

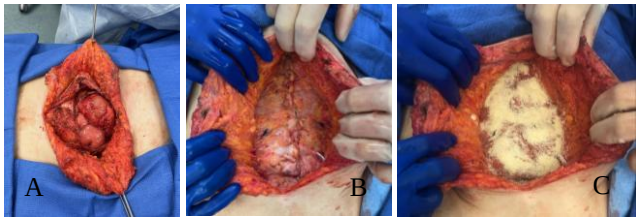

Figure 1. A. Open ventral hernia repair with dissection of the adipocutaneous, musculofascial, and visceral components. B. Closure of the abdominal wall fascia with visible sub-fascial drain placement present in the left lower quadrant after reduction of the visceral system. C. XCellistem Wound Powder incorporated in the abdominal wall closure in a uniform layer beneath the adipocutaneous system before additional placement of surgical drains throughout the same layer.

RESULTS

A total of 97 patients at our institution underwent open ventral hernia repair with abdominal wall reconstruction for a stage III ventral hernia. Of these 97 patients, 25 received XCelliStem during closure. Seroma and seroma-related complications were tracked in both groups. Among the 72 patients who did not receive XCelliStem, 49% (n=35) developed a seroma or seroma-related complication, compared to 16% (n=4) in the XCelliStem group (Figure 2). A Chi-squared test confirmed the difference to be statistically significant with a p-value of 0.0042. These results suggest a statistically significant association between the use of XCelliStem during closure and a reduction in seroma and seroma-related complications.

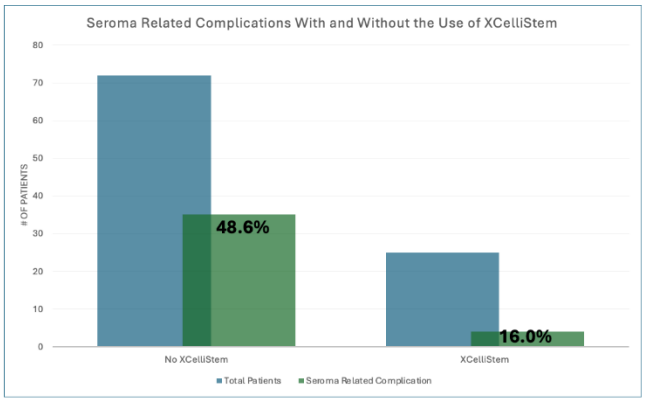

Figure 2. Rates of seroma and seroma-related complications identified in the XCelliStem and non-XCelliStem cohorts

DISCUSSION

Due to the sizable complication profile of complex abdominal wall reconstruction, several considerations must be accounted for to increase the chance of a successful outcome. The three major systems in play are the visceral, musculofascial, and adipocutaneous system. The visceral system is evaluated first when timing the repair of ventral hernias as the bowel and abdominal viscera must be definitively addressed prior to reconstruction. The

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musculofascial system is considered next and is the primary focus of hernia repair, as it contains full-thickness defects. The final component, often neglected is the adipocutaneous system, which acts as the driving force in seroma formation due to the robust lymphatic system of the abdominal wall which is disrupted during surgical dissection, the relative hypovascularity of the fat, as well as shear forces imparted on the tissues postoperatively.

Ventral hernia repair, particularly repairs requiring complex abdominal wall reconstruction, is plagued by seroma and seroma-related complications. Elevating the adipocutaneous layer from the anterior abdominal fascia disrupts the abdominal wall's lymphatic network, increasing the risk of seroma formation. In the absence of a gold standard of treatment, prevention and prophylaxis are essential to minimizing seroma-related issues, starting with meticulous surgical techniques such as hemostasis, minimization of dead space, and careful tissue handling.

Additional strategies have been employed to prevent seromas including chemical agents, pressure dressings, and surgical drains. Chemical agents, such as fibrin sealants or sclerosing agents are believed to reduce fluid accumulation by preventing lymphatic leakage following dissection. Pressure dressings, including abdominal binders or post-operative compression garments, help minimize dead space by tightly approximating the dissected planes. This compression also provides mechanical closure of the lymphatic ducts, reducing leakage and preventing seroma formation. Surgical drains are among the most commonly used techniques for seroma prevention, offering dual benefits by providing both suction and facilitating the evacuation of accumulating fluid.

Post-operative management of seromas is complex, with several factors requiring consideration. The size and location of the seroma play a significant role in determining appropriate management. Subclinical and small fluid collections can often be managed conservatively with compression garments, limb elevation, and watchful waiting. Surgeons must rely on their clinical judgment to decide when intervention is necessary, as management can be highly surgery-specific.

Aspiration of the seroma, whether performed blindly or with ultrasound guidance, is an option; however, it carries risks of infection and recurrence, despite sterile technique. In cases of recurrent seromas, low-dose radiation therapy has been used, particularly in breast surgery, with mixed results. Pharmacologic approaches, such as local corticosteroid injections, may also be employed to reduce inflammation and serous fluid production. In refractory or infected cases, surgical intervention may be required to excise the seroma cavity and revise the surgical wound.

The use of ECMs in wound healing and regenerative medicine has garnered significant interest, as various products have been applied across a wide range of surgeries, particularly in plastic and reconstructive surgery. ECMs utilize decellularized tissue to serve as a scaffold material, providing the body's inflammatory cascade with a structure to support accelerated tissue ingrowth. They contain functional molecules such as collagen, elastin, laminin, fibronectin, and growth factors, all crucial for tissue remodeling. Commercially available ECMs are derived from various donor tissues, selected to optimize the matrix composition, and provide the appropriate biomolecules and collagen types to promote healing. Recently, a Multi-Tissue Platform ECM (XCelliStem Wound Powder, RTT) was introduced, combining two donor tissues to provide a more balanced and robust blend of biomolecules, multiple collagen types, and growth factors. XCelliStem is a MTP xenograft derived from porcine lung and spleen tissues, selected for this study due to its demonstrated ability to accelerate healing. Porcine ECMs have been shown to promote epithelial cell penetration and fibroblast migration, while reducing seroma formation by enhancing tissue adhesion and neovascularization, thereby expediting wound healing.[14][15]

The incorporation of XCelliStem in stage III open ventral hernia repairs reduced seroma and seroma-related complications from 49% to 16%, despite the presence of comorbidities such as diabetes mellitus, obesity, tobacco use, and poor nutritional status. This study highlights the utility of integrating a MTP ECM during the open repair of stage III ventral hernias. It is important to note that while MTP ECMs offer a promising adjunctive tool for managing seroma formation, their full potential can only be achieved through meticulous surgical technique, appropriate drain use, and close patient follow-up.

LIMITATIONS

There are no limitations in this study

CONCLUSION

Based on our early experience with the use of XCelliStem, we have observed a significant reduction in seroma formation in complex ventral hernia repairs. As with all surgical interventions, patient selection is key, as factors such as age, obesity, and other comorbidities can affect both the risk of seroma development and the choice of treatment. Postoperative observation and care are essential, with regular check-ups playing a vital role in the early detection and management of seromas.

With treatment of seromas remaining elusive, we advocate for proactive mitigation in the perioperative period. A multidisciplinary approach, combined with meticulous surgical technique, judicious use of drains, and individualized patient care should be prioritized. Integrating novel therapies like XCelliStem into existing surgical practices offers a promising solution to a persistent complication. The significant reduction in seroma-related complications observed in this study highlights the potential of XCelliStem as a valuable component in complex open hernia repairs, representing a promising advancement in seroma prevention

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and mitigation.

FUTURE DIRECTIONS

These results represent a promising step forward in managing seroma formation in open ventral hernia repair. However, further studies with larger sample sizes and randomized control trials are needed to fully elucidate these findings and long-term outcomes of MTP ECMs like XCelliStem. Future research should also explore the broader role of MTPs in seroma management across various clinical settings, including breast surgery, panniculectomies, total joint revisions, and the evolving field of reconstructive surgery. Expanding the scope of research will be essential to unlocking the full potential of these therapies in minimizing seroma-related complications and improving patient outcomes across multiple specialties.

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