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Systematic Review

Management and repair strategies for abdominal perforations during abdominoplasty innovative techniques and clinical outcomes: a systematic review

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ABSTRACT

Current suture advancements in abdominoplasty and abdominal perforation repair have enhanced surgical outcomes. Innovations include antimicrobial sutures, which use agents like triclosan and silver nanoparticles to reduce surgical site infections without compromising suture integrity. Drug-eluting sutures release therapeutic agents directly at the wound site promote healing and reducing the need for systemic medications. Bioactive sutures and those seeded with stem cells aid tissue regeneration promising confirmed success in complex surgeries. Smart sutures featuring shape-memory polymers and electronic sutures that monitor physiological parameters represent cutting-edge developments. Barbed sutures eliminate the need for knots, distribute tension evenly, and decrease operative time. Mesh repair techniques come with biocompatible materials enhancing tissue integration and reducing complications. Endoscopic and laparoscopic approaches augmented by artificial intelligence and have further refined abdominal perforation repairs and offer superior outcomes. Fibrin sealants and adhesives have also seen improvements in efficacy, safety, and biocompatibility, with advances in synthetic alternatives and bioactive formulations further enhancing surgical success.

Keywords: Abdominal perforations, Abdominoplasty, Antimicrobial sutures, Drug-eluting sutures, Bioactive sutures, Stem cells

INTRODUCTION

Abdominoplasty, the so-called “tummy tuck, is cosmetic surgery which enhance the abdomen's appearance. It has gained popularity as it was the fourth most common aesthetic surgical procedure performed in the United States in 2019.[1] The origin of this abdominoplasty is traced back to the early 20th century with significant advancements in technique occurring throughout the 1960s and 1970s. Kelly and Pitanguy, the experts, pioneered methods that laid the groundwork for modern abdominoplasty while focusing on improving safety and aesthetic outcomes. The procedure includes excess skin and fat removal alongside the tightening of abdominal connective tissue (fascia). Post-surgery, remaining skin is repositioned and firmer, more contoured abdominal profile is obtained. Abdominal perforations incidence abdominoplasty is relatively rare but, it remains a

significant concern due to the potential severity of the complication. Research indicated that major complications including but not limited to abdominal perforations can possibly occur in 4% of abdominoplasty patients. Complications include hematomas, infections, blood clots, and lung-related problems, with hematomas being the most prevalent. Interestingly, Major complications risks increase when abdominoplasty is combined with other procedures and it may be reaching up to 10.4% in cases involving body contouring and liposuction. Despite the overall low incidence this problem already has profound impacts on patient outcomes and healthcare costs and it is important to ensure that patients undergo thorough preoperative evaluations and managing risk factors such as obesity and smoking can mitigate these risks.[2-4]

Etiology of abdominal deformity is pregnancy, while multiple pregnancies stretch skin beyond its biomechanical ability to retract and affect musculoaponeurotic structures of abdominal wall. It causes stretching and thinning of these structures and diastasis of the rectus muscles. Postpartum weight loss exacerbates this issue but if skin retraction has not occurred within approximately six months, it is unlikely to happen. Massive weight loss due to dieting or gastric bypass surgery contributes to excess skin and abdominal wall laxity.[1] Pathophysiology of abdominal deformity involves two main factors: excess skin or subcutaneous tissue and laxity of the abdominal wall musculature. A significant defective area is around and below the umbilicus where excess skin over a diastasis of the rectus muscles is most evident. In 1972, Georgiade and Katras classified fat deposits on the trunk into lower medial or upper medial based on the umbilicus. They divided patients into three categories: those with normal weight and those with mild-to-moderate obesity or those with massive weight loss.[1]

METHODS

We commenced with the objective of identifying and evaluating the most effective management and repair strategies for abdominal perforations occurring during abdominoplasty where we may focus on innovative techniques and clinical outcomes.

Study design

We decided to follow the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines to conduct a systematic review. We will address both qualitative and quantitative data while ensuring replicable approach. The process involved several stages: literature search, selection criteria application, data extraction, and analysis based on our inclusion and exclusion criteria.

Objective

Our primary objective was systematically review and critically assess the existing literature on management or repair strategies for abdominal perforations during abdominoplasty. We aimed to: identify the most effective and innovative repair techniques, evaluate clinical outcomes associated with these techniques, provide evidence-based recommendations for clinical practice, and highlight areas for future research and potential improvements in surgical protocols.

Literature search

Search was conducted across several major medical and scientific databases, including PubMed, Scopus, Embase, and the Cochrane Library and our search spanned publications from 2014 to 2023 to capture the most relevant and recent advancements.

Inclusion and exclusion criteria

Inclusion criteria

We included studies focusing on abdominal perforations during abdominoplasty. Research articles, clinical trials, case reports, and reviews discussing management and repair strategies were added. We considered publications in English. Studies reporting clinical outcomes of repair techniques and those papers describing innovative or novel techniques in managing abdominal perforations were included.

Exclusion criteria

Articles not directly related to abdominal perforations during abdominoplasty were excluded. Studies with insufficient data on management strategies or clinical outcomes, and non-peer-reviewed articles and grey literature was skipped. Publications in languages other than English without available translations were excluded as well. Duplicate studies or those with overlapping data sets were removed.

MeSH Terms and keywords for PubMed (NCBI)

Primary MeSH terms

Primary MeSH terms include "abdominoplasty", "abdominal injuries", "surgical procedures, operative", "postoperative complications", and "wound healing".

Secondary MeSH terms

Secondary keywords include “repair techniques,” “management strategies,” “clinical outcomes,” “surgical innovations,” and “postoperative complications” were our secondary key terms.

Search strings for PubMed (NCBI)

Search strings include: "Abdominoplasty"[MeSH] OR "Tummy Truck OR Abdominal Perforations "[MeSH]) AND "Repair techniques" OR "Management strategies" OR "Clinical outcomes" OR "Surgical innovations"; "Abdominoplasty"[MeSH] AND "Postoperative Complications"[MeSH]) OR "Abdominal wall perforation" OR "Abdominal surgery complications"; "Abdominoplasty"[MeSH] AND "Wound Healing" [MeSH]) OR "Management strategies" OR "Repair techniques" OR "Clinical outcomes"; and "Abdominoplasty"[MeSH]) AND "Novel procedures" [MeSH]) OR "Innovative techniques" OR "Surgical innovations".

Data extraction

Two reviewers performed Data extraction independently to minimize bias and ensure accuracy and first of all, results were filtered and most current studies were only selected to extract present information and what expectations we should have in the near future of abdominoplasty. When retrieving articles from databases, we applied other filters, such as selecting human studies, peer-reviewed journals, English language publications, and studies published within the last 10 years. Additional criteria may include specific study designs such as randomized controlled trials and cohort studies and systematic reviews to ensure high-quality and relevant data. The extracted data included: study design and methodology, patient demographics and sample size, types of perforations and causes, specific management and repair techniques used, immediate and long-term clinical outcomes, and complication rates and any noted innovations in techniques.

Data analysis

The data we collected was synthesized to identify common themes and efficacy of different techniques, and clinical outcomes. We analyzed quantitative data with appropriate statistical methods to compare the effectiveness of various strategies.

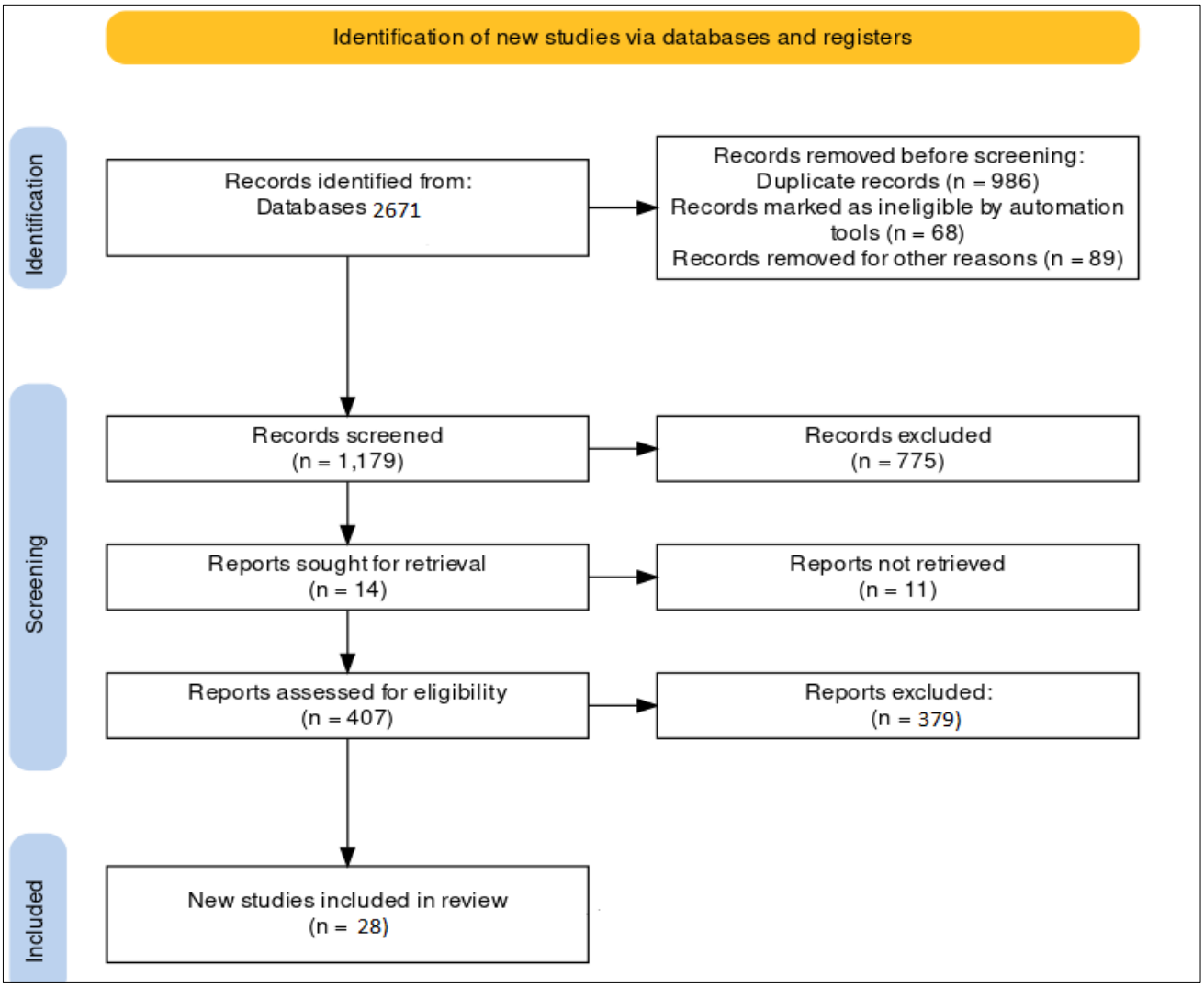

Figure 1: PRISMA.

RESULTS

In recent years sutures have seen remarkable advancements in abdominoplasty and the prompt repair of abdominal perforations. This evolution and innovation in technology of sutures is driven by the need for improved tissue convergence and enhanced healing processes and prevention from postoperative complications, infections and scarring.

DISCUSSION

Antimicrobial sutures

Suture technology advancement is antimicrobial sutures which reduce the risk of surgical site infections (SSIs) because these sutures are coated with antimicrobial agents triclosan a compound known for its broad-spectrum antibacterial properties. Sutures like vicryl plus are triclosan-coated, and they have shown efficacy in reducing bacterial colonization at the wound site without compromising the mechanical integrity of the suture silver nanoparticles (AgNPs) are available in markets and are now being used because of their potent antimicrobial effects. AgNP-coated sutures contain bacterial adhesion and proliferation which aid in reducing infections chances during the critical postoperative period.[5]

Drug-eluting sutures

Drug-eluting sutures are frontier in suture innovation, so these sutures deliver therapeutic agents directly to the wound site and improve the healing process while reducing systemic medication needs ultimately. There are techniques such as coating, grafting, or electrospinning that integrate drugs into the suture material; for example, sutures coated with antibiotics like tetracycline or levofloxacin show antibacterial activity effectively, reducing the incidence of SSIs. Also, these sutures can be engineered to release drugs in a controlled manner to ensure sustained therapeutic effects over time.[5]

Table 1: Previous evidence of clinical outcomes.[24]

Techniq-ue	Author/ date	Type of study	Objective	Methodology	Results	Conclusion
Primary suture repair[25]	Eric Swanson, 2023	Retrospe-ctive study	Evaluate aesthetic outcomes and complications in abdominoplasty	Analysis of 310 procedures (2016-2022) with total intravenous anesthesia, deep fascial anchoring sutures, single closed suction drain	300 women, 1-year follow-up. 35.8% complication rate, 5 deep venous thromboses, 15 seromas (4.8%), mean vertical scar level 9.9 cm	Total intravenous anesthesia is safe; avoiding electro dissection reduces seroma rates; deep fascial anchoring keeps scars low
Advanc-ed mesh repair techniq-ue[26]	Moharaq, 2024	Prospecti-ve retrospec-tive study	Compare traditional plication and non-absorbable mesh for rectus muscle diastasis	63 women, clinical exams, and CT imaging for recurrence, 33 mesh repair, 30 traditional plications	Mesh repair had longer hospital stay, both groups showed decreased waist circumference and inter-rectus distance, no recurrence	Mesh reinforcement may be indicated for diastasis above 4 cm in obese multiparous females
Laparos-copic surgery [27]	Nobuaki Hoshino, 2022	Nationwi-de epidemio-logic study	Compare laparoscopic versus open surgery for acute diffuse peritonitis	Data from Japan's National Clinical Database (2016-2019)	Open surgery more common in patients with poor condition, laparoscopic surgery had fewer complications, its usage increasing	Laparoscopic surgery may offer benefits for acute diffuse peritonitis, including reduced complications
Tissue adhesive-es (TAs) and fibrins[28]	Marwan W. Nasr, 2016	Systemat-ic review and meta-analysis	Review effects of TAs on seroma formation post-abdominoplasty	Review of Medline, Embase, Web of Science, Cochrane databases, 7 studies included, 5 RCTs	Similar seroma incidence with TAs, total drainage volume lower for TAs	Lack of high-quality evidence for TAs preventing seroma; well-designed RCTs needed

Bioactive and stem cell-seeded sutures

Bioactive sutures incorporate molecules such as growth factors, DNA, and stem cells enhance tissue regeneration and repair. Stem cell-seeded sutures give promising applications in tissue engineering and regenerative medicine and act as carriers for stem cells and facilitate their delivery to the injury site. For instance, those sutures seeded with mesenchymal stem cells have shown potential to improve wound healing by promoting collagen deposition and tissue regeneration and these approaches can be used frequently in complex surgical procedures like abdominoplasty where robust tissue repair is crucial.[5]

Smart and electronic sutures

These are modified types of sutures that are cutting-edge developments and are characterized by their ability to respond to environmental stimuli. Shape-memory polymers (SMPs) could be prime examples that offer self-tightening properties to simplify the suturing process, especially in minimally invasive surgeries. These sutures can return to their original shape when they get exposed to specific stimuli like heat, which ensures more secure and stable wound closure. Currently emerging revolutionary technology in sutures is electronic sutures because these have ability to monitor physiological parameters like temperature and pH while providing real-time data on the wound environment.[5]

Barbed sutures

Cutting-edge barbed sutures allow no use of knots. More and more often, they are utilized at the time of the abdominoplasty intervention and others. These sutures are spike-like along their length and work as if they are displacing tension in the tissue better and also reduce suture-related complications. Barbed sutures are easier to use and faster and take less time to sew. at the same time, they have a positive impact on wound healing since they cause the least harm to the tissue.[5]

Mesh repair techniques

Traditional polypropylene meshes are now being replaced since biocompatible materials such as polytetrafluoroethylene (PTFE) and biologic meshes has evolved.[6] These are the latest meshes that are aimed at reducing the risk of infection and inflammation while promoting better integration with the body's tissues. By combining synthetic and biological components, hybrid meshes come as a result, which offer the strength of synthetic materials and the biocompatibility of biologics. These kinds of meshes reduce foreign body reactions while maintaining structural integrity.[7]

Pre-peritoneal placement of meshes has also gained popularity as it provides robust support to the abdominal wall while reducing the risk of mesh exposure and infection and pre-peritoneal placement of meshes is more commonly used because it is beneficial in complex cases involving large defects or multiple previous surgeries. Surgical adhesives are increasingly used to secure meshes to avoid the complications associated with sutures or staples minimize tissue trauma and reduce the risk of post-operative pain and complications such as seroma formation.[8]

Recent evolution is meshing innovations like self-gripping meshes eliminate the need for additional fixation methods where these meshes adhere to the tissues independently simplifying the procedure and reducing operative time.[9]

Endoscopic and laparoscopic repairs

Endoscopic and laparoscopic approaches for abdominal perforations repairments during abdominoplasty has increased success rates and refined procedures. Minimally invasive methods offer superior visualization of abdominal cavities enabling precise identification and repair of perforations. Endoscopic and Laparoscopic techniques reduce incision size and minimize tissue damage and lower infection risk while accelerating the time of recoveries.[10]

Recent innovations include artificial intelligence (AI) integration to enhance surgical outcomes. AI algorithms provide real-time imaging analysis and facilitate enhanced visualizations and predictive analytics to identify potential complications before they occur. For instance, machine learning models are now available which are being used to predict the likelihood of perforation just by analysing patient data. AI-driven robotic systems enhance the precision of laparoscopic instruments enabling more accurate suturing and tissue manipulation.[11] Novel algorithms such as convolutional neural networks (CNNs) process intraoperative imaging data facilitating the detection of minute perforations that might be missed by the human eye. These are adapted to multiple intraoperative conditions ensuring consistent performance across different patient anatomies and surgical scenarios.[12]

Fibrin sealants and adhesives

Fibrin sealants and adhesives products mimic the final stages of the blood coagulation process creating a fibrin clot that aids in tissue adhesion and haemostasis and wound healing. Now, the main focus of clinicians and researchers is enhancing their efficacy and safety.[13] Abdominoplasty fibrin sealants reduce seroma formation a common complication. Advances include faster polymerization times and stronger adhesive properties which improve surgical outcomes and patient recovery. Products like Tisseel and Evicel are now formulated to offer better viscosity and flow which make product easier to apply and more effective in sealing large areas.[14] Fibrin sealants achieve hemostasis and tissue bonding in abdominal perforations and it works well in laparoscopic surgeries. It reduces the need for sutures and minimizes complications, and newer products, like Artiss, have higher elasticity and tensile strength which provide more

flexible application and better conformity to irregular surfaces.[15] New developments also focus on reducing immunogenicity and improving biocompatibility and now, companies are working on fibrin sealants that incorporate growth factors to enhance tissue regeneration and healing.[16]

Immunogenicity reduction includes purification processes where new purification methods are being developed to remove contaminants and immunogenic proteins from fibrin sealants, removing risks of immune responses and increases patient safety.[17] Recombinant DNA technology is utilized to produce fibrinogen and thrombin components resulting in a purer and more consistent product that minimizes immune reactions.[18] Now, there are other synthetic alternatives present in markets such as synthetic hydrogels which are recognized as one of the best alternatives to natural fibrin. Synthetic hydrogels are designed to mimic the properties of fibrin sealants without the risk of immunogenicity associated with animal-derived products.[19] Other current discoveries in biocompatibility enhancements for fibrin sealants and adhesives are bioactive molecules and their improved formulations, in these molecules, growth factors such as vascular endothelial growth factor (VEGF) and platelet-derived growth factor (PDGF) are added which promote tissue healing, reduce infections risks, and improve overall biocompatibility and regeneration.[20]

New formulations focus on elastomeric properties, such as those found in Artiss, which offer enhanced elasticity and tensile strength. These properties allow for better conformity to tissue surfaces and reduce mechanical irritation. Moreover, developing sealants with controlled degradation rates ensures they remain effective throughout the critical healing period without causing adverse reactions. Among recent effective products, Tisseel stands out with enhanced viscosity and flow properties, making it more effective in sealing large areas. Tisseel also uses advanced purification methods to reduce immunogenic components. Evicel is known for its easy application and strong adhesive properties which make it effective option for various surgical settings as this product incorporates recombinant technology to minimize immune responses. Artiss features improved flexibility and elasticity which is suitable for irregular tissue surfaces and it has biocompatibility and a lower risk of immune reaction compared to other adhesives.[21]

Peptide-based sealants and silk-based sealants mimic natural fibrin but are entirely synthetic thus reducing the risk of immunogenicity. Nanoparticle-enhanced sealants incorporate nanoparticles that enhance mechanical properties and bioactivity while promoting better tissue integration with better healing, and now these advancements are paving the way for safer and more effective surgical outcomes.[21,22] Companies like Baxter International and Ethicon are leading for their products as they offer rapid hemostasis and enhanced tissue adhesion and their formulations minimize immune response and comes up with better compatibility with human tissues making them safer for diverse surgical applications.[23,24]

Most recently, fibrin sealants come in liquid and powder forms and each form is tailored for specific medical needs. Liquid fibrin sealants such as Tisseel by Baxter are preferred for their ease of application and quick activation which makes it suitable for surgeries requiring rapid response while powder forms, on the other hand, offer precise control which makes it an ideal choice for delicate procedures like ophthalmic surgeries. Technological advancements have also introduced those fibrin sealants which comes with longer shelf life and improved safety profiles. For overall surgical procedures including abdominoplasty or abdominal perforations management, computational technology and AI use accelerate innovations while ensuring more effective and reliable products and now, partnerships like that of Grifols and Google Cloud are pioneering the integration of AI to enhance therapeutic development in near future.[23]

CONCLUSION

Novel innovations of sutures and repair techniques for abdominoplasty have improved surgical outcomes by enhancing tissue healing, reducing infection risks, and minimizing postoperative complications. Antimicrobial and drug-eluting sutures and bioactive and smart sutures represent critical advancements in this field and the shift to biocompatible mesh materials and the integration of AI in minimally invasive surgeries further enhance patient safety and recovery. Continued research and development in these areas hold promise for even more refined and effective surgical interventions which will ultimately lead to better patient care and outcomes with increased overall surgical success rate in abdominoplasty and abdominal perforations.

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