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COMPARATIVE EVALUATION OF ABSORBABLE, NON-ABSORBABLE AND AUTOLOGOUS MESH FOR HERNIORAPHY IN A RABBIT MODEL

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ABSTRACT

The breakage of abdominal muscles while skin remains intact is categorized as hernia. It may be either reducible or irreducible. The irreducible hernia is difficult to handle by simple methods and it requires attention. Abdominal anomalies related to trauma, rupturing of peritoneal membrane, and muscular dystrophy is common. Trauma is a common cause of abdominal rupturing in rabbits. *Hernias* are abnormal bulges due to weakness in the abdominal wall. A new technique is being introduced known as intra-abdominal mesh transplant that give better protection compared to sutures especially for herniorrhaphy. For the correction of abdominal hernias, two methods are being undertaken viz. auto graft and synthetic grafts. By the use of reconstruction surgery, abdominal cavity can be used as a tremendously rich reservoir of auotgenous vascularized tissue. The experimental study was designed and planned to be conducted on thirty Six (36) healthy, adult, indigenous rabbits ranging from 500-1000g in weight. The rabbits aged between 6 months to 1 year were selected. All thirty six rabbits were grouped into three major groups i.e., A, B, and C comprising 12 rabbits in each group. Group A rabbits were treated with Polypropylene mesh method technique. Group B rabbits were treated with polyglycolic acid mesh and Group C were corrected with Rectus Abdominis muscle technique. They were further divided into 2 subgroups consisting of having 6 male and 6 female in each sub-group. Wound healing was better in herniorrhaphy technique than hernioplasty. Recurrence of hernia is another complication of the hernioplasty and Herniorrhaphy. Recurrence after hernial repair due to the inadequate fixation of meshes, small size mesh and inappropriate adherence of the mesh with the muscles or fascia. Hernial recurrence rate, suture line, wound healing and other clinical observations study showed that Herniorrhaphy with rectus muscle grafting have advantages over polypropylene mesh and polyglycolic acid mesh.

Keywords: Polyglycolic acid mesh, Rectus Abdominis muscle, Polypropylene mesh, Hernipopathy, Rabbit

1. INTRODUCTION

Hernia is a Latin word which means "rupture" (Malangoni and Rosen 2007). Protrusion of internal organs through abdominal muscles is the common indication of hernia. Swelling is a classical sign of hernia. It can be easily corrected with surgery. The lump may be a harmless hematoma or lipoma in rare cases. It may be a cancerous tumour in certain circumstances. Herniation occur secondary to cystic structures and other space occupying masses. Metabolism of abdominal connective tissue can cause abdominal ruptures and recurrent hernias (Smolec *et al*. 2009). Hernia consists of three parts ring, sac and the contents. Actual defect is hernial ring its size may be of few centimetres to several centimetres. The hernial sac made up of tissues which contain hernial contents. The hernial content consists of organs and tissues that have moved to the abdominal location (Slatter. 2003). True hernias have defined ring and hernial contents are surrounded by a peritoneal sac (Shaw *et al*. 2003). The hernias produced due to trauma are classified as false hernia because they don't have hernial sac (Shaw *et al*. 2003; Slatter. 1985). Traumatic body wall hernias are more frequently developed in animals (Damschen *et al*. 1994; SHAHAR *et al*. 1997). Pre-pubic hernia may be caused due to traumatic hernia, in small animals ventral abdomen hernia usually develops due to rupture of pre-pubic tendon (Beittenmiller *et al*. 2009).

Abdominal anomalies related to trauma, rupturing of peritoneal membrane, and muscular dystrophy is common. Trauma is a common cause of abdominal rupturing in rabbits. *Hernias* are abnormal bulges due to weakness in the abdominal wall. The abdominal wall becomes swollen due to marked increase in weight and enlargement of abdominal viscera (Jahromi *et al*. 2009). Abdominal rupturing can be treated with conventional suturing technique. Sutures are easy to handle for edges binding. A new technique is being introduced known as intra-abdominal mesh transplant that give better protection compared to sutures especially for herniorrhaphy. Avian abdominal wall abnormalities pose a significant difficulty for avian veterinarians. According to Iannitti *et al*. (2008), the incidence of incisional hernias after laparotomy ranges from 2% to 20%, depending on the surgery type, closure method, and patient risk factor. Abdominal hernias resulted when the abdominal wall is severely injured and these hernias may be high or low in the flank, along the costal arch or between the last few ribs. The foreign objects that are usually sharp in nature cause severe trauma to abdominal muscles and results of rupturing. To repair an umbilical hernia, several procedures are used, including ligation of the hernial sac, the use of clamps, suturing of the hernial sac, mesh implants, and radical surgery; however, open herniorrhaphy is the most prevalent method of treatment. Although open hernia repair has numerous disadvantages, one of which is the risk of bacterial infection, which can lead to hernia reoccurrence. Prosthetic mesh is the greatest option for surgeons treating hernias. It is unknown if closed herniorrhaphy can reduce these consequences after surgery, although open herniorrhaphy is the only option for irreducible umbilical hernias (Smith *et al*. 2001). For the correction of abdominal hernias, two methods are being undertaken viz. auto graft and synthetic grafts. By the use of reconstruction surgery, abdominal cavity can be used as a tremendously rich reservoir of auotgenous vascularized tissue.

The use prosthetic materials for the surgical repair of abdominal wall defects has become almost standard practice. Pascual, G., *et al*. (2012). It is reported that prosthetic meshes cause peritoneal adhesions and pain but overall produce better results that cannot be neglected. Adhesions are fibrous bands that develop between the peritoneal areas where the prosthetic material is used between the serosal surfaces of different organs. The important circumstances that produce adhesion are previous surgeries, ischemia and foreign objects. Different kinds of prosthetic meshes available in market including light weight and heavy weight for the treatment of hernia (Peker *et al.* 2014).

2. MATERIAL AND METHOD

The experimental study aimed at evaluating various parameters in the hernial repair and focused on studying efficacy of different meshes like absorbable vs non absorbable vs autologous mesh under various risk factors, also comparing along with evaluating the predisposing or risk factors involved in herneoraphy and its postoperative complication. It was designed and planned to be conducted on thirty Six (36) healthy, adult, indigenous rabbits ranging from 500-1000g in weight. The rabbits aged

between 6 months to 1 year were selected. They were divided into three major groups i.e., A, B, and C comprising 12 rabbits in each group. Group A rabbits were treated with Polypropylene mesh method technique. Group B rabbits were treated with polyglycolic acid mesh and Group C were corrected with Rectus Abdominis muscle technique. They were further subdivided into 2 subgroups consisting of having 6 male and 6 female in each sub-group. They were kept in 12 separate cages (three rabbits/cage sized 86 × 76 × 86 cm) in the Department of CMS, UVAS, Lahore, Pakistan.

Before the research all rabbits were evaluated for prime health problems. The routine clinical evaluation was carried out. Hematological test was proceeded to check the normal CBC values, sugar, blood electrolyte. Animal were evaluated for any physical damage or injury. Blood tests were carried out for all the rabbits every 7 days post operation. Animals were evaluated for temperature, pulse rate and respiration.

Before the surgery: The experimental rabbits were observed carefully to determine their well-being. For aseptic surgical procedure, the surgical area was properly clipped 1 hour before surgery. The rabbits were kept in a sterilized location in the accessible place at the Department of Veterinary Surgery & Pet Sciences, UVAS, Lahore. In group A, B and C anesthesia was induced using xylazine-ketamine (5 mg/kg + 15 mg/kg) cocktail (Martin *et al*. 2009) while gas anesthesia (isoflorine) was used for maintenance. During the surgical procedure the rabbit was maintained in dorsal recumbence to be operated on ventral side.

a) **In Group A,** The induced abdominal wall defect or hernia was covered by using polypropylene mesh of larger size than the defect. The mesh was sutured to the fresh hernial ring. Mesh was extended 1.5 to 3 cm beyond the tissue margins. The polypropylene suture material was used to suture the mesh with tissue by using simple interrupted suture patterns. The abdominal wall was closed according to the routine procedure.
b) **In Group B,** The induced abdominal wall defect or hernia was covered by using polypropylene mesh of larger size than the defect. The devitalized tissue of the hernial content was excised. The mesh was sutured to the fresh hernial ring. Mesh was extended 1.5 to 3 cm beyond the vitalized tissue margins. The Polyglycolic acid suture material was used to suture the mesh with tissue by using simple interrupted suture patterns. The abdominal wall was closed according to the routine procedure.
c) **For Group C,** the rabbits were treated differently for the closure of the induced abdominal wall defect. The Component Separation Technique was used to extend the rectus abdominis muscle to repair large hernial defects of abdominal wall. The external oblique muscle was dissected from the internal oblique muscle in avascular way. The internal oblique muscle and transverse muscle remained intact; the blood loss and neurovascular bundles which enter to the inferior and superior epigastric vessels was preserved in this way. The anterior rectus was dissected along the aponeurosis of external oblique muscle. Rectus abdominis muscle was extended to the defect. Rectus muscle was advanced up to 10 cm by this technique. For future advancement rectus muscle was expurgated from the posterior sheath and attached to the internal oblique and transverse muscles. Abdominal wall was closed by using polypropylene material suture by approximation of anterior rectus sheath.

3. RESULTS

The following parameters were assessed to find out the efficacy of "Onlay" in absorbable, non-absorbable and autologous herinal repair techniques:

a) Healing of wound
b) Pain scoring
c) Formation of Abscess, Hematoma and Seroma
d) Histopathology
f) Ultrasonography

Table 1: Wound healing Polypropylene mesh

Days	Polypropylene mesh – Group A		Polyglycolic acid mesh – Group B	Rectus Abdominis muscle – Group C
≤ 7	4 (I, III, VI, IX)		2 (IV, VI)	2 (IV, VI)
8-13	7 (II, V, IV, VII, VIII, IX, XI)		6 (II, III, V, VII, VIII, X)	8 (I, II, III, V, VII, VIII, X)
14-21	1 (XII)		4 (I, IX, X, XI, XII)	2 (XI, XII)

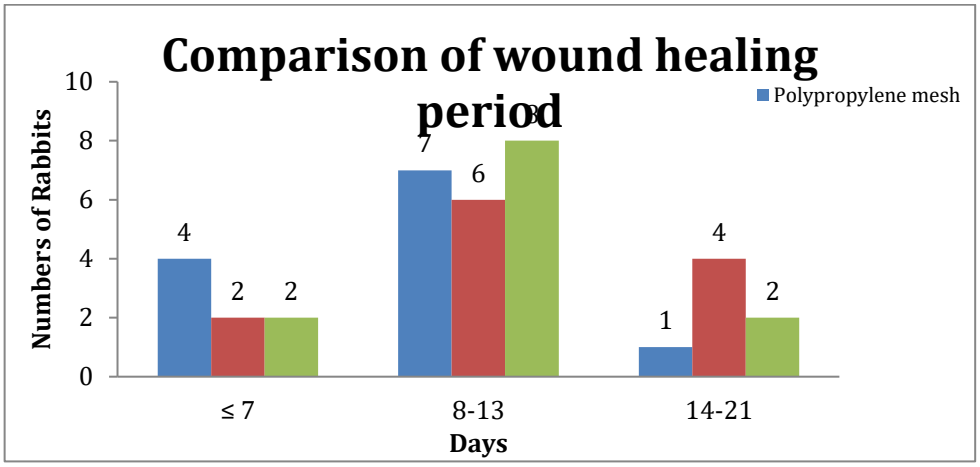

Figure 1: Graphical representation of wound healin period

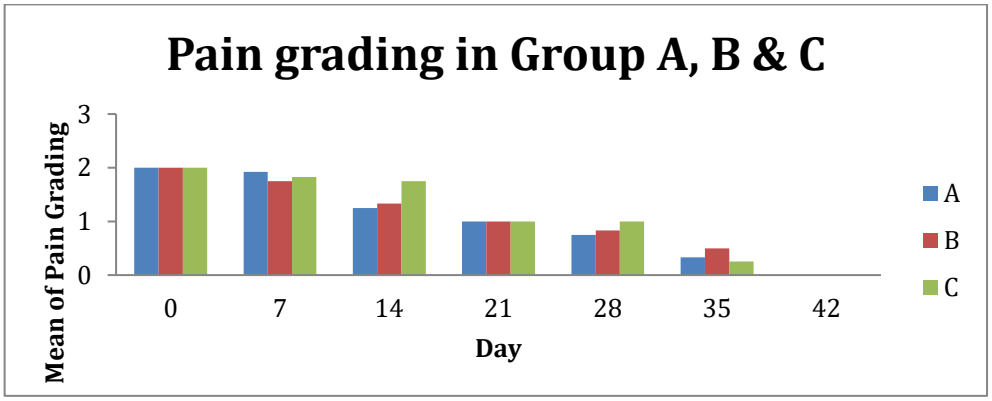

Figure 2: Graphical representation of pain mean values

In group A, mean pre-operative body temperature at 0 minute was 100.4°F. A slight increase in temperature was 100.6°F, observed at 10 minutes and 100.8°F at 20 minutes during surgery procedure. A gradual increase was seen up to 101.2°F at 30 minutes after completion of hernioplasty. In group B, mean pre-operative body temperature at 0 minute was 100.5°F. Then a gradual increase in temperature was seen 100.7°F at 10 minutes and 100.8°F at 20 minutes during hernioplasty. Then it gradually increased up to 101.2°F at 30 minutes after completion of surgery. In group C, mean pre-operative body temperature at 0 minute was 100.3°F. Then a gradual increase in temperature was seen 100.6°F at 10 minutes and 101.1°F at 20 minutes during herniorrhaphy. Then it gradually decreased up to 100.9°F at 30 minutes after completion of surgery.

Average pulse rate in group A was 185 beats per minute at 0 minute. It increased up to 193 beats 196 per minute at 10 minutes and 20 minutes respectively during hernioplasty with Polypropylene mesh. At 30 minutes it decreased up to 185 beats per minute during surgery. Average pulse rate in group B was 184 beats per minutes at 0 minute. It increased up to 193 beats per minute at 10 minutes and 195 beats per minute at 20 minutes during polyglycolic acid mesh grafting. At 30 minutes it decreased up to 191 beats per minute during grafting. Average pulse rate in group C was 179 beats per minutes at

0 minute. It increased up to 195 beats per minute at 10 minutes and 197 beats per minute at 20 minutes during polyglycolic acid mesh grafting. At 30 minutes it decreased up to 190 beats per minute during grafting Mean pulse rate (bpm) in group A (hernioplasty with Polypropylene mesh),

Mean pre-operative respiration rate in group A at 0 minute was 34 breaths per minute then during Polypropylene mesh hernioplasty a gradual increase of 38 breaths/minute and 43 breaths/minute was observed at 10 minutes and 20 minutes respectively. It increased up to 47 breaths per minute at 30 minutes after Polypropylene mesh hernioplasty. In group B, mean pre-operative respiration rate at 0 minute was 35 breaths per minute then it increased up to 40 breaths/ minute and 43 breaths/minute at 10 minutes and 20 minutes respectively during surgery. At 30 minute it decreased up to 46 breaths per minute herniorrhaphy. In group C, mean respiration rate at 0 minute was 35 breaths/minute then it increased up to 40 breaths/minute and 42 breaths/minutes at 10 minutes and 20 minutes respectively during surgery. At 30 minute it increased up to 44 breaths per minute Abdominis muscle herniorrhaphy. Mean respiration rate (breaths per minute) in group A (hernioplasty with polyglycolic acid mesh), group B (herniorrhaphy with polyglycolic acid mesh) and group C (Rectus Abdominis muscle grafting).

In group A average pre-operative red blood cells count was 6.39×10^{12}/L. At day 7 it decreased up to 6.18×1012/L and further decreased at 14th day up to 5.41×10^{12}/L after Polypropylene mesh Hernioplasty Mean red blood cells count in group B was 6.65×10^{12}/L at day 0 and decreased at day 7 up to 6.58×10^{12}/L and 5.89×10^{12}/L up to day 14 of polyglycolic acid mesh. Mean red blood cells count in group C was 6.90×10^{12}/L at day 0 and decreased at day 7 up to 6.86×10^{12}/L and 6.31×10^{12}/L up to day 14 of Rectus Abdominis muscle.Mean red blood cells count (10^{12}/L) in group A (Polypropylene mesh Hernioplasty mash), group B polyglycolic acid mesh) and Rectus Abdominis muscle .Normal value of RBC's in rabbit is 5-8×1012/L.

Mean pre-operative WBC's count in group A was 8.05×10^{9} /L At day 7 increased up to 8.36×109 /L and gradual decreased at day 14 up to 8.21×10^{9} /L after surgery. In group B, mean WBC's count at day 0 was 8.26×10^{9} /L and then decreased up to 7.85×10^{9} /L at day 7th and 8.13×10^{9} /L up to day 14th of polyglycolic acid mesh grafting. In group C mean WBC's count at day 0 was 8.04×10^{9} /L and then increased up to 8.45×10^{9} /L at day 7 and 8.33×10^{9} /L up to day 14th of Rectus Abdominis muscle grafting. Mean white blood cells count (109 /L) in group A (Polypropylene mesh Hernioplasty), group B (polyglycolic acid mesh) and group C (Rectus Abdominis muscle). Normal value of WBC's in rabbit is 5.2- 12.8×10^{9} /L.

Estimation Mean packed cell volume in group A was 40 (%) at 0 day. At day 7 it decreased up to 36 (%) and gradual increased up to 37(%) at day 14th during Polypropylene mesh. In group B, mean packed cell volume at day 0 was 38(%) at day 0 and decreased up to 35 (%) at day 7th and increased upto 38 (%) at 14th day of Herniorrhaphy. In group C, mean packed cell volume at day 0 was 36(%) at day 0 and increased up to 37 (%) at day 7th and slihghtly decreased upto 36 (%) at 14th day of Herniorrhaphy. Mean packed cell volume (%) in group A (Polypropylene mesh Hernioplasty), in group B (polyglycolic acid mesh) and group C (Rectus Abdominis muscle Grafting. Normal value of PCV in rabbit is 33-50%.

In group A, mean hemoglobin estimation at day 0 was 12.6 g/d/L. At say 7th it decreased slightly up to 12.2 g/L and gradual increased at 14th day up to 12.5 g/L during with Polypropylene mesh Hernioplasty. In group B, mean hemoglobin estimation was 13.0 g/L at day 0 and 12.3 g/L at day 7th, then gradual increased up to 12.5 g//L at day 14th of polyglycolic acid mesh. In group C, mean hemoglobin estimation was 12.60 g/L at day 0 and 12.3 g/L at day 7th, then gradual increased up to 12.4 g//L at day 14th of Rectus Abdominis muscle. Mean hemoglobin (g/dL) in group A (with Polypropylene mesh Hernioplasty), group B (polyglycolic acid mesh) and group C (Rectus Abdominis muscle) .Normal value of hemoglobin in rabbit is 10-17g/L.

An ultrasonography performed to check either the internal suture line was intact or not of the hernial defect. After Hernioplasty with mesh the internal suture line remains intact in some cases. In group B there was minimum suture line brakeage because of advance techniques. In group A the mesh was used which shrinks with time due to which there was more chances of brakeage of the suture line. In group C due to muscles the sutures remain intact as there was no muscle shrinkage.

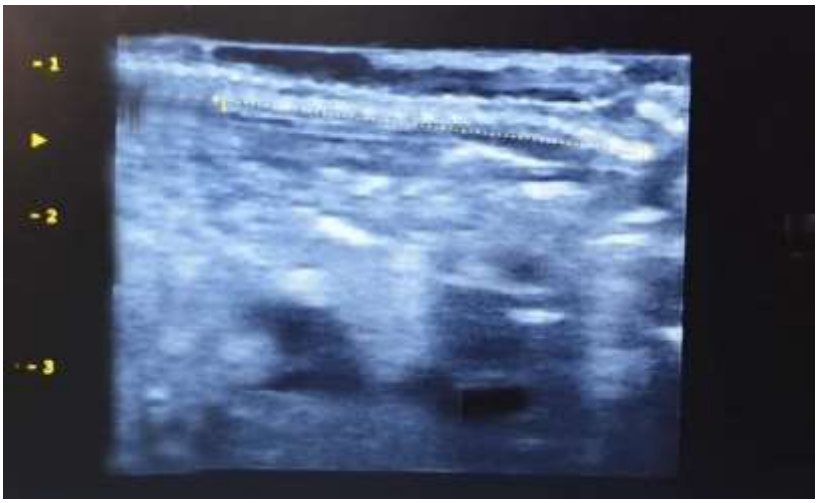

Figure 3: Mesh seen to insure the sutures presence**.**

In group A the mesh is placed with simple interrupted suture pattern to close the paramedian hernial defect. There are more chances of propylene mesh adhesions with muscle layer of the rabbit. After postmortem there were more adhesions seen in group A rabbits whereas, there was no external material like mesh to close the hernial defects in group B thus minimal chances of adhesions in this case. Similarly, in Group C Postmortem shows minimum adhesions.

Wound healing was accessed on the basis of any type of exudate, wound surface area, pain observation on physical examination and size of the wound i-e length, width and depth. In group A polypropylene mesh was used which is an external material caused infection which effects the wound healing in some cases. In group B polyglycolic acid mesh was used to repair the hernial defect in some cases it caused infection which effected the wound healing during postoperative care. In group C Rectus Abdominis muscle tecnique was as there was no external material to repair the hernial defect so there was no such issues were seen during postoperative care Healing was categorized as start of healing (S), mild healing (M), moderate healing (M2), proper healed (P) and not healed (N). There are four stages of healing epithelization, inflammation, fibrosis and angiogenesis. Wound healing in group A (Hernioplasty) and group B, C (Herniorrhaphy).

4. DISCUSSION

The efficacy of absorbable vs non absorbable vs autologous were evaluated on the basis of parameters like Healing of wound , Pain scoring, Formation of Abscess, Hematoma and Seroma, Histopathology, Ultrasonography

Average pre-operative red blood cells counts were statistically, the differences between time intervals within group was significant as P value was 0.22 ($P>0.05$) and was non-significant between time intervals and groups with P value 0.82 ($P>0.05$). Mean WBC's increased at day 7th and day 14th after surgery in all groups and non-significant between time intervals and groups with P value 0.95 ($P>0.05$). Mean packed cell volumes were statistically, the differences between time intervals within group and between groups was significant as P value was ($p<0.05$). In group A, mean hemoglobin at day 7th it decreased up to 11.4 g/L and gradual increased at 14th day up to 12.2 g/L during surgery. In group B, 11.4 g/L at day 7th, then gradual increased up to 12.2 g//L at day 14th. Statistically, the differences between group A and group B and Group C was significant ($P<0.05$).

A gradual decrease in temperature was observed at 10 minutes and at 20 minutes during surgery procedure. A gradual increase was seen at 30 minutes after completion of the surgery in Group A but gradual decrease was seen at 30 min in group B, whereas in group C gradual decrease was seen at 30 min. The differences between time intervals was significant within groups as P value was 0.000 ($p<0.05$). Animal faces hypothermia and loss of blood during surgery (Barker *et al*. 1987). Average pulse rate was increased at 10 minutes at 20 minutes during surgery. At 30 minutes it decreased during surgery in all groups. During surgery due to anesthesia the pulse rate also effected due to trauma

(Watterson *et al*. 2005). Increase in mean pre-operative respiration rate was observed at 10 minutes and at 20 minutes during surgery. It decreased at 30 minutes after surgery in all groups. The differences within groups was significant as P value was 0.000 ($p<0.05$).

There are more chances of propylene mesh adhesions with muscle layer of the rabbit. After postmortem there are more adhesions seen in group A. In group C there was no external material like mesh to close the hernial defects so minimum chances of adhesions in this case. Postmortem showed minimum adhesions. Adhesions are the basic problem of hernial repairs. There were no adhesions in advanced Herniorrhaphy technique (rectus muscle grafting) but there are adhesions in mesh hernioplasty technique and polyglycolic acid mesh and polypropline mesh. Polypropylene mesh shows inferior qualities which effects the ultimately life of the patient (Novitsky *et al.* 2007). Polypropylene mesh in a rabbit model revealed the formation of adhesions, polyglycolic acid mesh revealed the formation of adhesions. Mean adhesions in an experimental study were significantly greater ($P< 0.02$) than ePTFE meshes. Pore size of the mesh is critical for the adhesions formation in hernio-graphy procedures (Matthews *et al*. 2003).

Wound healing was better in herniorrhaphy technique than hernioplasty. Recurrence of hernia is another complication of the hernioplasty and Herniorrhaphy. Recurrence after hernial repair due to the inadequate fixation of meshes, small size mesh and inappropriate adherence of the mesh with the muscles or fascia (MacFadyen Jr *et al*.1994).

CONCLUSION

Hernioplasty and Herniorrhaphy exhibit slight differences in complication rates for hernia repair. Studies show Herniorrhaphy with rectus muscle grafting has advantages over Polypropylene and polyglycolic acid meshes, particularly in terms of wound healing and clinical outcomes. Key parameters such as wound healing, pain, abscess formation, hematoma, seroma, histopathology, and ultrasonography were evaluated. Statistically, the time interval differences within groups were significant ($P<0.05$) for various metrics like packed cell volumes, while between-group differences were generally non-significant. Herniorrhaphy demonstrated better healing and fewer adhesions compared to mesh-based hernioplasty techniques. Postmortem analysis revealed minimal adhesions in Herniorrhaphy, highlighting it as a superior method for hernia repair. Herniorrhaphy also showed fewer complications such as hernia recurrence, likely due to better fixation and integration of the graft with surrounding tissues. Thus, Herniorrhaphy, particularly with rectus muscle grafting, presents a more effective and less complication-prone alternative to traditional mesh-based Hernioplasty. Herniorrhaphy and hernioplasty will help to repair the hernial defect. Herniorrhaphy will be more helpful for the animal to avoid complications due to hernia and will restore the organ functionality.

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