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Ultrasound and Radiograph Mesh Hernia Graft 3D Imaging Correlation; Study in Rabbits

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ABSTRACT
A Mesh hernia graft is needed to prevent recurrent hernias. This study aimed to observe the biocompatibility of hernia mesh graft as an alternative material for handling hernia cases via surgery for small animals. This study used 6 male rabbits aged 6-8 months and weighted 1.5-2 kg which were divided into 2 groups. Group 1 was not implanted and had the peritoneum, muscles dan skin sutured, while group 2 was implanted by 3D hernia mesh graft and sutured by the peritoneum, muscles dan skin. Ultrasound and radiograph evaluation were performed on day 6th, 12th, and 24th after surgery. The radiograph evaluation with a left lateral view of the body was performed to evaluate changes in density, whereas ultrasound imaging of the dorsal hypogastric region around the implant area was performed for interpretation of echogenicity. The ultrasound imaging of the dorsal hypogastric region around the implant showed anechoic echogenicity in group 2 on day 12, but on the same day group 1 only showed hyperechoic echogenicity features. In both treatment groups at day 12, the results of X-ray showed inflammation around the incision area with low-density radiopaque image visible. This study showed that the mesh hernia graft has good biocompatibility and is well accepted by the body.

Keywords: *Mesh hernia graft 3D, ultrasound, radiography*

1. INTRODUCTION

Hernia is an abnormal protuberance of an organ, part of organ, or tissue in the abdomen through a normal or abnormal cavity (ring) by the abdominal wall or diaphragm [1]. Clinically, hernia is comprised of hernia ring, hernia content, and hernia sack. Based on its type, hernia is divided into reducible and irreducible [2]. The principle of hernia treatment is by returning the herniated content into the abdomen and close the hernia cavity through surgical procedure [3].

Hernia treatment is performed by returning herniated content to its default position and closing hernia ring by suturing both side of hernia ring. The formation of fibrous layer between hernia ring caused the two hernia rings hard to combine. Thus, although the hernia ring had been sutured together there is still possibility to rupture again [4]. In this kind of condition, veterinarians are required to use mesh graft membrane. Moreover, for hernias located in certain locations, mesh graft membrane is needed due to the limited availability of tissue around the hernia grafts [5].

The difficulty in obtaining mesh graft membrane made veterinary medical services get increasingly expensive and unaffordable by the people. This is due to the high import cost of medical items into Indonesia, which raised the cost of implants [6]. Mesh graft membrane may originate from the same species (allograft) or different species (xenograft). Ultra-High Molecular Weight Polyethylene (UHMWPE) polymer is a synthetic product that has been commonly used in medical world as implant material [7].

Application of UHMPWPE material has been attempted for knee implant as this material has high wear resistance, low friction, and biocompatible [8]. This research aimed to determine the biocompatibility of three-dimensional model mesh graft generated from UHMPWPE material by using 3D printing process for hernia case treatment through the use of imaging examination utilizing 3D ultrasonography (USG)

equipped with linear transducer (10-13 MHz) and Direct-Radiography (DR-Xray) digital roentgen.

2. MATERIALS AND METHODS

2.1. Research procedure

This study used 6 male rabbits, with body weight (BW) 1,5-2 kg and age between 6-8 months which were divided into 2 groups. Each rabbit was acclimatized for 2 weeks. During acclimatization the rabbits were given ciprofloxacin (Ciprofloxacin®, Hexpharm Jaya, Indonesia) 15 mg/kg BW 2 times a day for 6 days orally as antibiotics and ivermectin as antiparasitic (Intermectin®, Interchemie, Holland) 0,2 mg/kg BW 1 time for 2 weeks subcutaneously (SC). Commercial feed and water were given ad libitum. All rabbits were kept in individual cages with a size of 50 cm x 50 cm.

Rabbits were fasted for 8 hours and then given atropine sulphate as pre-medication (Atropine®, Ethica, Indonesia) 0.05 mg/kg BW SC, and a combination of ketamine 10% (Ketamil®, Troy Laboratories PTY Limited, Australia) 35 mg/kg IM and xylazine 2% (Xyla®, Interchemie, Holland) 5 mg/kg IM as general anaesthesia [9]. Group 1 was not implanted with the peritoneum, muscles dan skin were sutured, while group 2 was implanted by 3D mesh hernia graft by the peritoneum, muscles dan skin. Ultrasound and radiograph evaluation were performed on day 6, 12, and 24 after surgery. The radiograph evaluation of left lateral view of the body was performed to evaluate changes in density, whereas ultrasound imaging of the dorsal hypogastric region around the implant area was performed for interpretation of echogenicity. The ultrasound imaging of the dorsal hypogastric region around the implant showed anechoic echogenicity in group 2 on day 12, but on the same day group 1 only showed hyperechoic echogenicity features. In both treatment groups at day 12, the results of X-ray showed inflammation around the incision area with low-density radiopaque image visible.

2.2. Data Analysis

Data obtained were analyzed qualitatively and quantitatively by analysis of variance one way ANOVA with confidence interval 95%. Data of significant difference would be followed by Duncan test. All quantitative data were processed by statistical package for social science (SPSS) 21 software.

3. RESULTS AND DISCUSSION

This research displayed the use of hernia mesh graft from UHMPWPE polymer material generated by 3D printing process in the treatment of hernia cases evaluated by imaging examination through the use of 3D ultrasonography (USG) equipped by linear transducer (10-13 MHz) and Direct-Radiography (DR-Xray) digital roentgen, which can be accepted by the body and is biocompatible. USG and DR-Xray imaging in group 1 and 2 are presented in Figure 1 and 2.

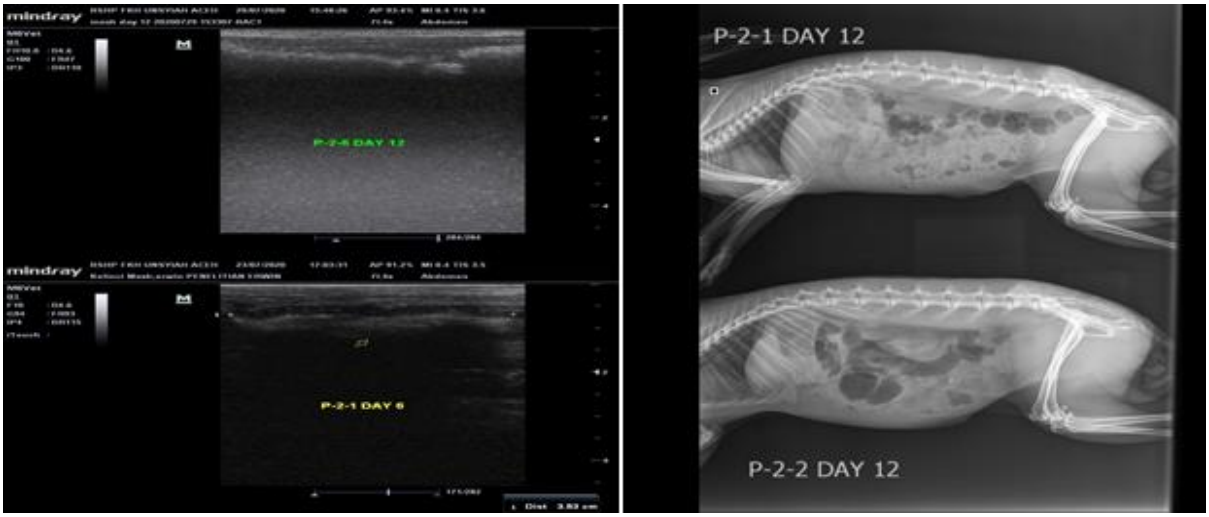

Figure 1. Rabbit ultrasonography and DR-Xray imaging of dorsal hypogastrium region around implanted area on day 6 and 12.

Ultrasonography imaging of dorsal hypogastrium region around the implant area for group 2 in day 6 and 12 showed anechoic echogenicity feature. However, on the same day group 1 only showed hyperechoic echogenicity. DR-Xray imaging in both treatment group in day 6 and 12 showed inflammation around implant area with low radiopaque density (Figure 1). In day 24 post implant, ultrasonography result of the area around implant showed echogenicity features similar with the surrounding tissue. DR-Xray of day 24 on

both treatment group also showed that abdominal area and area surrounding implant no longer showed inflammation.

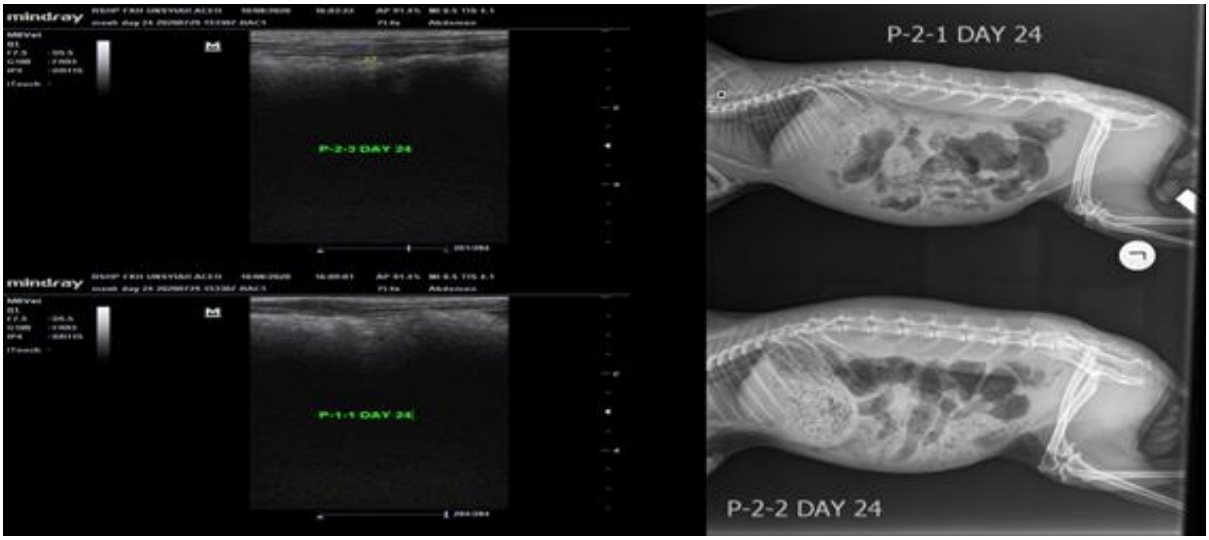

Figure 2. Rabbit ultrasonography and DR-Xray imaging of dorsal hypogastrium region around implanted area on day 24.

The main responses against the presence of mesh graft material are the formation of palmitic protein layers such as albumin, IgG and fibrinogen by the area around the implant soon after implantation [9]. This protein is known to interact with cellular components such as thrombocyte, monocyte, macrophage, and polymorphonuclear leucocyte involved in inflammatory response [10]. This caused USG imaging in group 2 on day 6 and 12 to show anechoic echogenicity and DR-Xray imaging on the same day to show the presence of inflammation.

In its progress on the initial stage of inflammation due to implantation, several factors such as thrombocyte growth, fibroblast proliferation, IgF, EgF, FgF, and TgF β, would be activated and important in hernia recovery process [11]. A week after implantation, phagocytic mononuclear cell differentiated into macrophages. These cells release effectors assisting in the modulation of inflammatory response and the last stage of this biological response is the synthesis of connective tissue especially collagen as a form of wound recovery. This stage lasted for 21 days [12]. This matches the DR-Xray imaging result on day 24 post mesh graft implant on both treatment groups which showed abdominal area around implant no longer feature inflammation, peritoneum closed perfectly, and mesh graft had fused with peritoneum and abdominal musculature. USG imaging on day 24 on both treatment group also showed echogenicity result similar with the tissue surrounding mesh graft implant area. Mesh graft from polymer material is one of the choices for the treatment of hernia cases due to its biological response, low side effect, and reduced possible post-surgery infection in hernia cases 13].

4. CONCLUSION

Hernia mesh graft has good biocompatibility and is accepted by the body.

AUTHORS' CONTRIBUTIONS

This research was designed by EE and AA. Field work and laboratory work were performed by EE, NY, AA, EE, and ZZ. This article was authored by NY, EE, AA and EE.

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