Journal of Pediatric Surgery 50 (2015) 1264–1268

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Protective effect of early placement of nasogastric tube with solid dilator on tissue damage and stricture formation after caustic esophageal burns in rabbits☆,☆☆

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ARTICLE INFO

Article history:
Received 31 August 2014
Received in revised form 19 November 2014
Accepted 21 November 2014

Key words:
Esophagus
Caustic
Burns
Nasogastric-tube
Pathology
Rabbit

ABSTRACT

Background: The ingestion of caustic substances remains an important public health issue worldwide. Children represent 80% of the ingestion injury population globally. Accidental alkaline material accounts for most caustic ingestions. There is no conclusive evidence of tissue damage and stricture protection of a nasogastric-tube with a solid dilator in the literature, therefore it was hypothesized that early intraesophageal tube placement does not cause additional histopathologic damage and prevents strictures.
Methods: An exploratory study on experimental caustic esophageal burns in a rabbit model was designed. In the treated group a silicone tube was placed immediately after causing the burns, while the untreated group followed the natural course of the burn. On the twenty-second day, an esophagectomy was performed on all animals for microscopic (Histopathologic Damage Score and Stenosis Index) and macroscopic analysis.
Results: Forty animals were randomly divided into two groups. The Histopathologic Damage Score was 3.7 ± 1.1 in the treated group versus 3.9 ± 1.2 in the untreated group ($p = .9690$). The Stenosis Index was 0.6 ± 0.1 in treated rabbits versus 2.3 ± 0.2 in untreated ($p < .0001$).
Conclusion: The early placement of an intraesophageal tube with solid dilator prevents stenosis formation and does not produce greater tissue damage.

The ingestion of caustic substances remains an important public health issue worldwide despite educational and regulatory efforts intended to reduce its occurrence [1]. These injuries are still increasing in developing countries [2], related to social, economic, and educational factors and mainly to a lack of prevention [3,4]. Worldwide, children represent 80% of the ingestion injury population [5], primarily because of accidental ingestion [6].

Alkaline material accounts for most caustic ingestions in Western countries [7]. Alkalis combine with tissue proteins, cause liquefactive necrosis and saponification, and penetrate deeper into tissues. Additionally, alkali absorption leads to thrombosis in blood vessels, impeding blood flow to already damaged tissue [8,9].

Experimental findings suggest that arteriolar and venular thrombosis with consequent ischemia may be more important than inflammation in the pathogenesis of acute corrosive injury. Four to seven days after ingestion, mucosal sloughing and bacterial invasion are the main findings. Simultaneously, granulation tissue appears, and ulcers become covered by fibrin. Perforation may occur during this period if ulceration exceeds the muscle plane. Fibroblasts appear at the injury site around day four, and around day five, an "esophageal mold" is formed, consisting of dead cells and secretions. Esophageal repair usually begins on the tenth day; stenosis formation occurs on day twenty-one and is complete from one to two mounts after ingestion [10]. The tensile strength of the healing tissue is low during the first three weeks since collagen deposition may not begin until the second week. Scar retraction begins by the third week and may continue for several months, resulting in stricture formation and shortening of the involved segment of the gastrointestinal tract. Additionally, lower esophageal sphincter pressure becomes impaired, leading to increased gastroesophageal reflux (GER), which in turn accelerates stricture formation [11]. When it comes to deciphering the systemic and cellular mechanisms involved in the hypermetabolic response to burn injury, evidence supports the use of larger animals. To resolve the complexities and high costs associated with large animal burn models, rabbits are not only relatively large animals that maintain a metabolic relevance to humans, they are an appropriate animal model for studying burns induced by hypermetabolism and their pathological alterations in energy homeostasis because they share with humans several aspects of their metabolism, such as similarities in composition of Apo lipoprotein B (Apo B)-containing

☆ Conflict of interest: The authors declare no conflict of interest.
☆☆ All authors meet the following conditions: a) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data and b) drafting the manuscript or revising it critically for important intellectual content.

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http://dx.doi.org/10.1016/j.jpedsurg.2014.11.040
0022-3468/

lipoproteins, hepatic production of Apo B 100-containing very low dense lipoproteins (VLDL), human-like Apo B, and low hepatic lipase activity. It has also been shown that rabbits present elevated REE (resting energy expenditure) levels post-thermal injury, which is a characteristic metabolic feature in burn patients. [12]. Although the biomechanical and histological properties of two-layer esophagi animals (particularly rodents) are still insufficient, the similarity in biological reaction time after burns between rabbit and human esophagi is well documented [13].

Immediate treatment is usually conservative, as the definitive extent of the injury is determined within minutes after ingestion, which is why a preventive stricture strategy is critical. Though a tube may be helpful to ensure patency of the esophageal lumen, the tube itself could contribute to the development of long strictures or esophageal perforation and routine use is not uniformly recommended [1,14]. Any esophageal catheterization may be a nest for infection, and nasogastric placement may worsen gastroesophageal reflux in this patient population, with a consequent delay in mucosal healing. Should a tight stricture develop, positioning a tube has the advantage of providing a lumen for dilatation. Therefore placing a tube may be considered after caustic injuries, but the decision should be made on a case-by-case basis and it is essential to proceed with caution.

There are no conclusive studies in the literature on the effects of an intraesophageal tube with a solid dilator placed immediately after burns either on tissue damage, or stricture prevention. Therefore, the hypothesis that immediately placing an intraesophageal tube would not cause additional histopathologic damage and might even prevent strictures was proposed.

The aim of this work was to describe in an experimental caustic burn model the effect of early intraesophageal tube placement on Histopathologic Damage Score and Stenosis Index.

1. Materials and methods

1.1. Ethics statement

The study was approved by the Animal Ethics Institutional Committee, Faculty of Medical Sciences, National University of Cordoba (Argentina) and conformed to the Guide for the Care and Use of Laboratory Animals (U.S. NIH Publication # 85-23).

1.2. Study groups

An exploratory experimental study on a rabbit model was designed.

Forty prepubertal male California four to five-month-old rabbits weighing between 2400 and 2650 g were randomly allocated into two groups. The normal dimension of a four- to five-month-old rabbit's esophagus is 13–15 cm in length and 10–12 mm in diameter (2–3 mm in wall thickness and 4–6 mm in lumen diameter).

All rabbits were kept in conditions of 22 °C ± 2 °C, with a controlled light cycle (twelve-hour day, twelve-hour night). The animals were fed with standard balanced food pellets and water *ad libitum*.

In the control group the esophagus was injured and left untreated. In the treated group, the esophagus was injured and therefore received immediate treatment by means of introducing of a malleable silicon nasogastric tube with a metal mandrel through the nose, which had a radiopaque silicon solid dilator mounted collinearly in its middle part, intended to be located in the injured area, fixed firmly by the elasticity and surface tension of the materials, inside the nasogastric tube. Once the nasogastric tube was placed, the guide was removed, and surgically affixed. This device was designed and manufactured by Silmag Biomedical Products Co. (Cordoba, Argentina) (Fig. 1). The distal tail of a nasogastric tube lodged in the stomach and the proximal tail was fixed at the nostrils (please see the schema in Fig. 2). The solid silicone dilator was 9 cm in length and 2 French (0.66 mm) in diameter.

The animals were fasted twelve hours before the procedure. Each rabbit was anesthetized using acepromazine, ketamine, xylazine and atropine intravenously. Animals received sufficient fluids during the procedure (0.9% sodium chloride solution and 5% dextrose). The vital signs were monitored until complete anesthetic recuperation. Subsequently the rabbits received Ibuprofen 5 mg/kg IV every 6–8 hours (Actron™—Bayer Labratories) according to necessity [15], and Cephalexin 25 mg/kg IV every 6 hours (Keforal™—Ivax Laboratories) was administrated for fourteen days. The drugs were administered to both groups simultaneously, to avoid differences attributable to their pharmacological effects.

1.3. Experimental esophageal burns model

The following method was used to create experimental esophageal burn: the animals underwent a rigid esophagoscopy and circumferential swabbing on the upper and middle third of the esophagus with 10% NaOH (pH 13.8) for one minute, and then washed with (0.9% sodium chloride solution and 5% dextrose). Immediately the burn was corroborated by esophagoscopy and the tube with permanent solid dilator was placed at the site of the injury in the treated group. Finally a gastrostomy was performed for feeding purposes (Stamm technique) with a silicone button (1.2 cm in length and 18 French in diameter) manufactured by Silmag Biomedical Products Co. (Cordoba, Argentina)

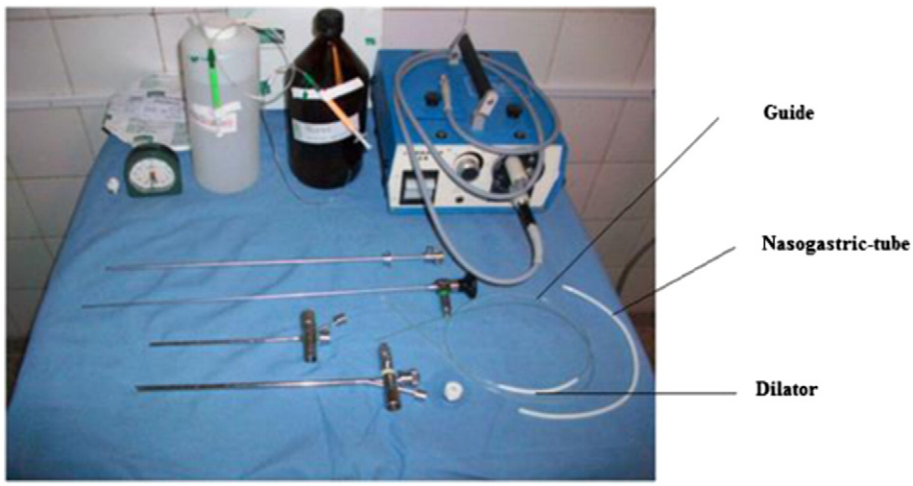

Fig. 1. Silicon nasogastric tube with solid dilator used in the study. Malleable silicon stent with a metal guide and a radiopaque solid silicon dilator mounted in its middle part to be placed at the site of the injury (lower right corner). Silmag Biomedical Products Co™.