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REVIEW

Treatment of the liver cross section following hepatectomy

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Summary The incidence of complications after hepatectomy has been considerably reduced over the last 20 years. Better knowledge of liver anatomy and liver regeneration, and methods preventing bleeding during surgery have resulted in morbidity rates below 20% and mortality rates less than 5%. The treatment of the liver cross section remains controversial. Experimental studies have reported convincing biological effects of fibrin sealants or compresses when applied on the liver to decrease hemorrhagic or biliary complications. However, clinical studies are very heterogeneous, providing conflicting results compromising recommendations for routine use.

Introduction

Technical advances in liver surgery have reduced the incidence of postoperative complications after major hepatectomy. Morbidity ranges from 5 to 15%, with mortality less than 5% [1].

Despite this important reduction in mortality, estimated at 20% 35 years ago [2], the risks of intraoperative bleeding and postoperative hemorrhage after hepatectomy remain challenging problems with transfusion rates at 5 to 10% [3,4] and high rates of biliary complications, 3.6 to 12%, depending on the series reported [5—8].

Obtaining and maintaining a dry hepatectomy cross section depends on several important factors related to the anesthesia, the surgical procedure and the patient.

In order to optimize imperfect hemostasis of the liver cross section or to prevent postoperative bleeding or fistulization, several ''dressings'' have been proposed for the liver

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cross section. Although experimental and clinical evidence is abundant in the literature, the level of proof of efficacy remains low. Debate on appropriate indications remains open. We wanted to summarize current knowledge of different techniques and products used for this purpose.

Hemorrhagic risk of liver surgery

Control of intraoperative bleeding has been a major objective for the improvement of patient management since intra- and postoperative blood loss is a factor predictive of postoperative complications [3,9—12]. Transfusion of blood-derived products is associated with its own significant morbidity. Reduced blood lost during surgery has been made possible by advances in surgery (improved knowledge of liver anatomy described by Claude Couinaud [13], optimized transection of the hepatic parenchyma [14—16], vessel clamping methods [17,18]) and in anesthesia (limited vascular filling, low central venous pressure, pharmacological prevention of ischemia-reperfusion lesions).

Results reported by Poon et al. [12] illustrate the dramatic reduction in perioperative transfusions which involved 90% of patients in 1989 and 5% in 2003, a reduction made possible by optimized management.

During this same period, preventive hemostatic ''dressings'' became a controversial subject. Different products and techniques for treating the liver cross section have been reported based on experience with their use in liver traumatology.

Omentoplasty

Before the advent of complex materials, certain authors described diverse omentoplasty techniques as salvage procedures for uncontrollable bleeding. Survival rates were encouraging [19,20]. From 1971 to 1974, Stone et al. reported permanent control of 32 cases of massive traumatic liver hemorrhages in 37 patients who underwent hemostatic packing using a pediculized omentum flap [19].

In a prospective randomized trial, Paquet et al. compared the preventive effect of omentoplasty applied on the liver cross section on the development of postoperative complications. The overall rate of complications was 12.6% in the omentoplasty group versus 18.7% in the control group, a difference which did not reach statistical significance. This study did not provide sufficient evidence to affirm the superiority of this technique which is not recommended for scheduled procedures [21].

Cellulose

Regenerated oxidized cellulose has been used as a local hemostatic sealant since the 1950s [22,23]. Its hemostatic efficacy after liver laceration or hepatectomy has been demonstrated in several experimental animal models where time to control bleeding was generally used to evaluate outcome. Blair et al. reported a model of liver resection in the rabbit where the cellulose sealant provided significantly superior efficacy compared with cotton compresses (the control group) as measured by time to control bleeding (19 min versus 15 min) [24]. Davidson et al. compared hemostasis of the hepatectomy cross section in a swine model and found that a fibrin-derived sealant had a superior effect over a cellulose sealant. Measured in terms of time to control bleeding and volume of blood loss, outcomes were equivalent [25].

Collagen

Local application of collagen has been validated as an effective treatment for bleeding [26,27] and several products have been proposed (sponges, compresses, powder, in association with fibrin derivatives). The key property of collagen (main component of the extracellular matrix) is its mechanical adhesive effect. Applied on a zone requiring treatment, it serves as a matrix for the formation of the platelet clot by improving physiological platelet aggregation and activation of coagulation factors. In a hepatectomy model in the rat, application of collagen covered and adhered to 95% of the cross section surface in one minute, allowing rapid effective hemostasis [28] justifying its choice as the gold standard in clinical studies devoted to hemostasis of the liver cross section [29,30].

Argon beam coagulation

Experimental work with the dog model validated the coagulation effects of argon laser and the feasibility of its use after severe liver trauma. Bleeding was controlled in 100% of cases (versus 10% in the control group) with a three-fold reduction in time to control bleeding compared with standard methods (cellulose, collagen) [31]. Although this was an experimental study, its conclusion led certain authors to prefer this method as the gold standard [32].

Improvement in the classical technique can be obtained by applying concentrated albumin on the cross section [33]. Extracellular collagen within an electrocoagulated tissue plays the role of a biological glue forming bridges between contiguous tissues [34], a phenomenon which is amplified by the adjunction of albumin. Results in an animal model have been encouraging, essentially in terms of more rapid control of hemostasis [33,35]. These results have yet to be validated with comparative studies but appear to be confirmed in a study of clinical feasibility published in 2009 [36].

Fibrin derivatives and pharmacological associations

Products derived from fibrin and fibrinogen have been widely used for hemostatic purposes over the last 20 years for different types of surgery, and in liver surgery to improve hemostasis of the liver cross section. The pharmacological objective is to reproduce hemostatic biological mechanisms. Prothrombin is activated to thrombin by the catalytic action of thromboplastin and ionized calcium. The second phase of coagulation is the polymerization of fibrin monomers originating from fibrinogen and activated thrombin. Besides the hemostatic properties, the semi-rigid fibrin clot formed also intervenes in scar formation by stimulating local adhesion of fibroblasts. Commercially available products have variable compositions resulting from successive adaptations and modifications of dosages of the key components: fibrinogen, thrombin, factor XIII, ionized calcium, anti-fibrinolytic factors (aprotinine). Speed of clot formation, clot adherence and durability can be affected, modifying fibrin polymerization and thus clot formation [37,38]. The various compositions (thrombin alone, thrombin + fibrinogen, collagen + thrombin, collagen + thrombin + fibrinogen, etc.) and formulations (glue, compress, sponge, etc.) [39] are all designed