

Editorial

Modern technology, liver surgery and transplantation

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Since the first right hepatectomy performed by Jean-Louis Lortat-Jacob on October 16, 1951 and the first liver transplantation by Thomas Earl Starzl on March 1, 1963, hepatobiliary surgery and liver transplantation had a spectacular development [1,2]. After the hesitating beginning in the 1950's and 1960's, their evolution really took off in the 1980', reaching high-speed velocity in the 21st century. Improved knowledge of the (surgical) anatomy, refinement of techniques together with better insights into the (regenerative) physiopathology of the liver led to the development not only of precise surgical techniques but also to carefully-thought surgical strategies combining locoregional and systemic therapies [3–9]. Indeed, a multidisciplinary approach allowed to broaden the access of many patients to a curative treatment. Partial or total hepatectomy after downstaging and/or volume enhancing procedures using advanced locoregional and/or systemic therapies allowed to develop the concepts of two-stage hepatectomy, Associating Liver Partition and Portal vein ligation for Staged hepatectomy (ALPPS), Intra-Operative UltraSonography-guided (IOUS) parenchymal sparing hepatectomy and liver resection using *in-situ* cooling as well as reduced-size, split, Resection And Partial liver transplantation with Delayed hepatectomy (RAPID) and living donor liver transplantation (LDLT) [2,9–16].

The liver was initially thought to be an organ “not fit for surgery” because containing too many vascular structures. Severe hemorrhagic complications were indeed responsible for a prohibitively high peri-operative morbidity and mortality. This negative downward spiral was transformed into an upward positive spiral based on the relentless pioneering work of personalities such as Ton That Thung, Hiroshi Hasegawa, Masatoshi Makuuchi, Rudolph

Pichlmayr, Henri Bismuth and Thomas Starzl [2,4,13,17]. Partial and total hepatectomy has nowadays become safe treatments for million of patients worldwide.

The parenchymal division of the liver evolved from Ton That Thung's “simple” finger fracture technique via “Kellyclasia” toward Cavitron UltraSonic Aspiration (CUSA) or hydrojet based parenchymal division [4,17,18]. Many more new instruments and devices allow to plan and realize “surgical precision procedures”.

In this special issue of *Hepatobiliary & Pancreatic Diseases International* several of these new technologies have been brought together.

The introduction of indocyanin green (ICG)-fluorescence-guided surgery became an important addition to the intraoperative ultrasound allowing to perfect segmental and sectorial liver resections [6,18,19]. The Tokyo group led by Norihiro Kokudo highlights the importance of this technique in parenchymal sparing liver resections [20].

Enormous progress has been made in the field of “classic” imaging of the hepatobiliary diseases and structures [21]. 2D and 3D imaging and printing will allow to procure extremely valuable additional information in relation to the tumoral process, the accompanying Glissonean pedicles and more importantly the resected and residual functional liver volumes. This information will become more and more important in the near future in the rapidly developing fields of both advanced and living donor hepatectomies [12,16,18]. Jian-Peng Liu from the Shulan group in Hangzhou led by Shu-Sen Zheng gives a literature review about this new technology in both fields of liver surgery [22]. Deniz Balci from Istanbul showed that living donor hepatectomy can be perfectly planned based on a locally developed software program that precisely identifies biliovascular structures and segmental volumetry (to be published) [23].

Liver transplantation, initially designed by Starzl to treat unresectable, primary and secondary liver tumors, has regained its place in transplant oncology [2]. The integration of the dynamic morphologic and biologic behavior of hepatobiliary tumors has allowed to extend, safely and justifiedly, the inclusion criteria for transplantation [24]. A question mark still remains about the pre-transplant identification of the most important prognostic factor, *i.e.*, vascular invasion. The multicenter study published by Jing-Wei Wei led by Jie Tian from Beijing allowed to accurately predict macrovascular invasion in a large series of hepatocellular carcinoma patients based on a computed tomography (CT)-based

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quantitative clinical-radiomics integrated model (CRIM). Specific radiomics signatures are on the way to answer this important question in the field of transplant oncology [25].

Liver transplantation should occupy a more important part in the decision making process in relation to hepatobiliary cancer. Indeed in too many centers (even top centers!) “a wall” still exists between liver resection and liver transplant surgeons. This situation is at great disadvantage for many patients because denying access to a curative treatment. Indeed it has been clearly shown in many studies that the long-term results of liver transplantation for primary (and recently even secondary) cancers are far superior to those obtained after partial liver resection [26]. To allow more access to a curative transplantation only three ways exist i.e., promote deceased organ donation, develop further split liver transplantation techniques and finally develop on a worldwide scale LDLT [16,27,28].

Complete safety whilst obtaining a nice esthetic results are two conditions to spread more widely the application of LDLT. To comply with these donor requirements minimally invasive donor hepatectomy needs to become the standard [29–32]. The Riyadh group led by Dieter Broering convincingly showed that robotic donor hepatectomy is on the way to comply with this future standard of care [33]. Their experience should stimulate other liver transplant centers to embark on a robotic donor project. It is important to stress in this context that LDLT will occupy a central role in what we termed for the first time in literature in 2015, transplant oncology, because allowing to plan the surgical procedure perfectly in between neo- and eventual adjuvant chemotherapy [28,34]. Recent evidence exists that immuno- and chemotherapy and immunosuppression can indeed be combined safely [35,36]. The next step in the evolution of LDLT will be to realize also the allograft implantation using a minimally invasive approach. Zhe Feng led by Yi Lv from Xi'an set the first step by showing the feasibility of vascular suturing using magnetic vascular anastomosis rings (MVAR) in a laparoscopic large animal liver transplantation model [37].

Decision making based on artificial intelligence (AI) is increasingly present in all major sectors of modern civilization including agriculture, science, economy and medicine. Surgeons are well positioned to integrate AI into modern practice. In recent years, models based on deep-learning have begun to be used in surgery, oncology and organ transplantation [38,39]. Javier Briceno from Córdoba (Spain) [40] showed that artificial neural network (ANN) and random forest (RF) models built on a multitude of donor-recipient (D-R), logistic and perioperative variables allow the successful allocation of allografts in over 80% of D-R pairings, a number much higher than obtained with the conventionally used D-R scoring or matching systems. Such result is very important because it indirectly allows to enlarge the scarce (deceased) donor pool by eliminating avoidable allograft losses. Many barriers still need to be overcome before deep-learning-based models will become routine in practice, the main one being the resistance of the clinicians to leave their own decision to autonomous computational models.

For sure the last words about the application of modern technology in the fields of hepatobiliary and liver transplantation surgery have not yet been said. Surgeons should further work *hand in hand* with (medical) engineers and scientists to cautiously introduce further technical advancements aiming at the highest quality of care, also taking into account costs and the fundamental doctor-patient relationship.

Without any doubt, modern technology has revolutionized the way that surgery is taught and practiced today. The door is widely opened...one thing should however always be kept in mind “not to confound in surgery means and aims”!

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