# Arterial anastomosis without rotation in adult living donor liver transplantation: a modification to the back-wall-first technique

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**Objective**
In this article, we report our experience with a modification of the back-wall-first technique for hepatic arterial anastomosis in living donor liver transplantation.
**Patients and methods**
Fifty-one adult living donor liver transplantations (49 modified right lobes and two left lobes) were performed in El-Rajhi Liver Hospital, Assiut University, Egypt, in the period from November 2014 till September 2019. All patients were included. All donors were related to the recipients. Arterial anastomoses were performed under ×6 loupes magnification. Without placing stay sutures, stitching was started in the back-wall by interrupted stitches that were tied immediately without hanging, followed by front-wall stitches in a similar manner. No rotation was applied to the arteries and no bulldog clamps were placed on the donor arteries on most occasions.
**Results**
The mean donor age was 25.6±5.9 years; 22 (43.1%) were males. The mean BMI was 25.3±1.9. The mean recipient age was 50.4±11.1 years; there were 37 males (72.5%). The mean BMI was 26.9±4.7. The mean donor artery length and diameter were 14±2.1 and 2.2±0.11 mm, respectively. The donor artery used was the right hepatic artery in 49 patients (96.1%) and the left hepatic artery in two patients (3.9%). Among the recipients the right hepatic artery was used in 36 patients (70.6%), the left hepatic artery in 11 patients (21.5%), the splenic artery in three patients (5.9%), and the common hepatic artery in one patient (2%). Hepatic artery thrombosis occurred once (2%). The median follow-up was 33 months (range, 9–69 months).
**Conclusions**
Hepatic arterial anastomosis without rotation of the artery has low risk of hepatic artery thrombosis.

**Keywords:**
hepatic artery anastomosis, hepatic artery thrombosis, intimal dissection, liver transplantation, living donor

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## Introduction

Hepatic artery thrombosis is the most devastating complication that can ever occur in liver transplantation and especially in living donor liver transplantation (LDLT), where the risk is higher due to the smaller size of the donor's artery(s) [1,2]. Graft failure is inevitable and retransplantation is the only hope then, which is not always possible or available, especially in countries that lack deceased donation [2]. To decrease this risk, many innovations and modifications have been devised for the technique of hepatic artery anastomosis to decrease this risk.

In this article, we report our experience with a modification to the back-wall-first hepatic arterial anastomosis.

## Patients and methods

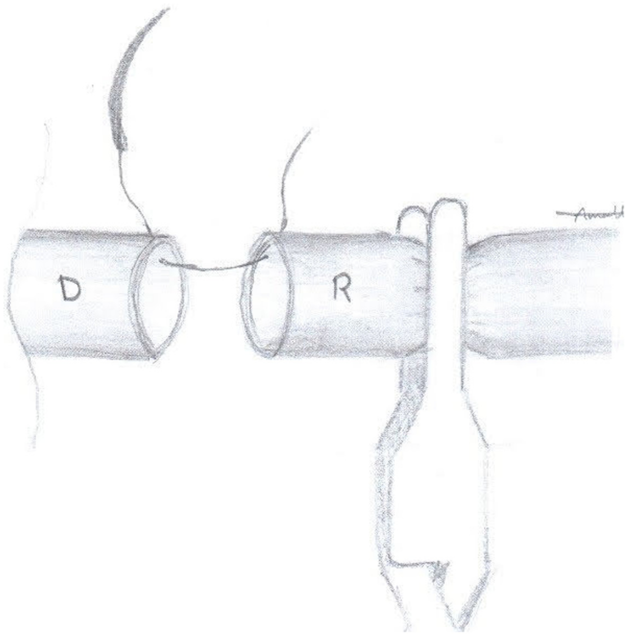
Fifty-one adult LDLTs were performed in El-Rajhi Liver Hospital, Assiut University, a tertiary-level university hospital dedicated to hepatobiliary disorders and liver transplantation in Upper Egypt, in the period from November 2014 till September 2019. All patients were included in this study. All data were collected from a prospectively maintained database. Ethical approval was obtained from the Ethical Committee of Faculty of Medicine, Assiut University. All patients signed, prospectively, an informed consent that indicated that their data would be stored in an electronic database and the data would possibly be published maintaining their anonymity. All donors were older than 18 years of age and all were related to the recipients (up to the fourth degree). Unrelated donation is not allowed in the hospital.

For modified right lobe LDLT, in the donor side, during hilar dissection, the right hepatic artery and the right portal vein were dissected free from the right hilar plate. After completion of parenchymal transection and hilar plate transection, the artery was transfixed by 5/0 Prolene suture (Ethicon, Somerville, New Jersey, USA) and then transected, followed by clamping and transecting of the right portal vein, and then finally, the right hepatic vein was stapled and transected. On the back-table, no flushing to the artery was performed. Its diameter and length were measured and recorded. In the recipient side, high transection of hepatic arteries was performed. After resecting the native liver, and placing the grafted liver, the hepatic veins were anastomosed initially, followed by the portal vein, and then reperfusion was performed by declamping both veins. Then, the hepatic artery and biliary reconstruction were performed.

**Details of the arterial anastomosis**

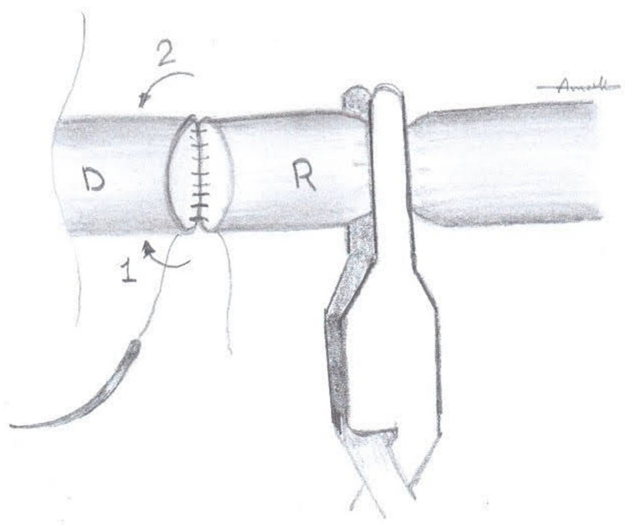
Anastomoses were performed under ×6 surgical loupes magnification. No bulldog clamps were placed on the donor side unless there was excessive back flush, occurred in less than one third of the donors. Continuous irrigation of the field, especially the donor artery, by heparinized saline was performed to enhance visibility. Anterograde flushing of the recipient's artery was performed before commencing anastomosis to ensure that no clots developed. Retrograde flushing of the donor artery with heparinized saline was not preferable for fear of intimal injury, but if required, an olive-tip metal cannula was favored over arterial or venous polyurethane cannulae and gentle flushing was used without actually inserting the metal cannula into the donor's artery. The suture used was 8/0 Prolene if the diameter of the donor artery was larger than 2 mm and 9/0 if it was less than 2 mm. The first stitch was placed at the farthest point in the recipient side from outside to inside and then from inside to outside in the donor side; then, it was tied and both short ends were cut as no hanging or hooking to thread-ends was used in this technique as shown in Fig. 1. Subsequently, interrupted stitches were placed using the exact method moving stepwise from the far end to the near end along the back-wall. Any discrepancies in

**Figure 1**




Schematic drawing of modified back-wall-first hepatic artery anastomosis. The recipient artery (R) is clamped by a single bulldog clamp. The first suture is placed at the back-wall. D, donor artery.

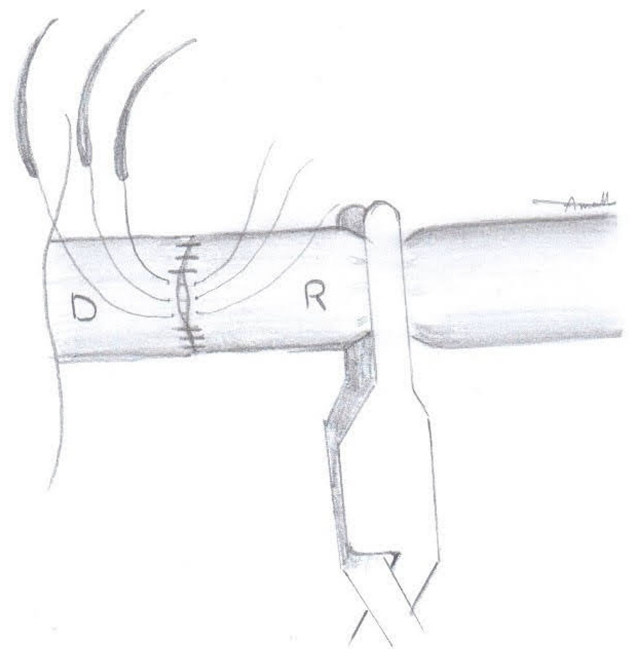
**Figure 2**




The back-wall is completed by interrupted stitches. The next three stitches will be in the direction of (1) arrow, followed by stitching in the direction of (2) arrow. R, recipient artery; D, donor artery.

diameters were adjusted along the course of the stitches. Stitches were placed very close to the edge and close to each other; thus, each side would accommodate at least eight stitches as shown in Fig. 2. Once the near corner was reached, stitching was continued on the front wall from the near end to the far end for further three or four stitches, which were all tied, and short ends were cut as well. Then, the next stitch was placed at the far end, close to the initial stitch

**Figure 3**




The final three stitches of the front-wall are left untied till all three are placed; then, they are tied. R, recipient artery; D, donor artery.

and then further three stitches were placed moving from the far end to the near end. The final three stitches were left untied and were attached lightly without pulling to lightweight bulldog clamps till all three stitches were placed as shown in Fig. 3. If reflushing of the recipient artery was required at this point, a lightweight bulldog clamp was lightly applied temporarily to the donor side. The bulldog clamp on the recipient side was released temporarily for an anterograde flush of any clot that may had developed during the time of the anastomosis and to confirm a good flow. The remaining stitches were then tied and finally the recipient's bulldog clamp was removed. An immediate color Doppler was performed to confirm flow.

Postoperatively, color Doppler was repeated daily for 7 days, then weekly till discharge, then monthly in the outpatient clinic up to 6 months, and then on demand thereafter. There was a low threshold to order contrast-enhanced early arterial computed tomography for the liver if there were any aberrations in the clinical, laboratory, or radiological findings that may point to the possibility of hepatic artery thrombosis.

### Statistical analysis

Categorical variables were presented as numbers and percentages, and continuous variables were expressed as mean and SD.

## Results

Of 51 LDLTs performed, 49 were modified right lobe (without middle hepatic vein) LDLTs and the remaining two were left lobe donations. The mean donor age was 25.6±5.9 years; there were 22 males (43.1%). The mean BMI was 25.3±1.9. All donors were related to the recipients: 31 (60.8%) daughters and sons, four (7.8%) spouses, four (7.8%) mothers, one (2%) father, and 11 (21.6%) were up to the fourth degree. The mean recipient age was 50.4±11.1 years; there were 37 males (72.5%). The mean BMI was 26.9 ±4.7, and the etiology of liver disease was the hepatitis C virus in 36 patients (70.6%), autoimmune hepatitis in seven patients (13.7%), hepatitis B virus in six patients (11.7%), Budd–Chiari syndrome in one patient (2%), and cryptogenic in one patient (2%). The mean model for end-stage liver disease score was 16.22±3.5, the mean graft weight to recipient weight ratio was 1.1±0.16, the mean cold ischemic time was 33.2±11 min, and the mean warm ischemic time was 34.1±5.5 min.

The mean donor artery length and diameter were 14 ±2.1 and 2.2±0.11 mm, respectively. The donor artery used for arterial anastomosis was the right hepatic artery in 49 donors (96.1%) and the left hepatic artery in two donors (3.9%). Redo of arterial anastomosis was required in three cases, where Doppler flow was not adequate, and the anastomoses were taken down, trimmed back on the donor side, and the same artery (two occasions) or a different artery (one occasion) was used in the recipient side. The final Doppler was satisfactory on all three occasions. The final recipient artery used was the right hepatic artery in 36 patients (70.6%), the left hepatic artery in 11 patients (21.5%), the splenic artery in three patients (5.9%), and the common hepatic artery in one patient (2%).

Hepatic artery thrombosis occurred once (2%). In this patient, the operative details were not remarkable, with good Doppler flow at the end of anastomosis, but the flow was lost immediately after the operation. Therefore, relaparotomy was performed and the anastomosis was taken down and a thrombus developed at the site of anastomosis. It was evacuated and extensive flushing of the donor side by heparinized saline was performed. The distal end was trimmed on the donor side till a healthy part of the artery was reached. The recipient's left hepatic artery was selected for the second anastomosis after ligating the previously used right artery. The new anastomosis was performed using the same technique. The immediate postoperative course was uneventful, with deliberate adjustment of the international normalized ratio above 2.5 by the continuous administration of heparin. Unfortunately, on the fifth postoperative day, the Doppler flow was lost again without any other laboratory or clinical remarks. Another laparotomy was performed and it revealed the presence of a thrombus that extended inside the donor's artery and some of its major branches. Thrombectomy was performed, trimming of the donor's artery was performed in a similar manner, and anastomosis to the recipient's splenic artery was performed after freeing it. Unfortunately, the arterial flow could not be fully traced in different segments of the graft. Over the next six postoperative days, the patient developed gradual liver failure, followed by multiorgan failure. Retransplantation was not an option due to nonavailability of another suitable related donor and the absence of deceased donation in Egypt.

Apart from the above-mentioned episode, no other patients developed hepatic artery thrombosis, and on four occasions, the arterial flow was temporarily not clear on Doppler, where computed tomography confirmed arterial patency and liver arterial perfusion. The median follow-up was 33 months (range, 9–69 months).

## Discussion

The arterial anastomosis in the LDLT is unique and is different from arterial anastomoses in other circumstances. First, the arteries lie deep in the abdomen. There is always discrepancy in the diameters. The liver graft is still ischemic and the anastomosis has to be quickly performed, or graft damage may ensue. The donor artery is usually short; only a few millimeters are available for handling and any damage to it before or during the anastomosis may require resection of a part of it, and subsequently, it becomes more challenging to accomplish a safe arterial anastomosis [1,2].

There are many techniques that are safely used by surgeons for hepatic artery anastomosis during LDLT. Each technique has its merits and disadvantages. As there is no universal technique, there is still room for improvement and innovation. Classically, arterial anastomosis is performed by placing two bulldog clamps on recipient and donor arteries, and then either the front-wall or the back-wall is finished first, by either interrupted sutures that are placed untied initially and tied later after placing the last stitch or in a continuous manner mostly using the parachute technique [1]. Then, both bulldog clamps are rotated 180° to expose the other wall and the process is repeated [1,3]. Many reports showed that both interrupted and continuous stitches are safe and reproducible [1,4,5]. This technique, despite being commonly used, has a few risks, such as the possible trauma to the arteries during the rotation period, potential damage by the jaws of the bulldog clamps to the delicate donor artery, and the possible shear to the intimas if excessively pulled by the hanged threads [6].

One of the advantages of placing the back-wall row initially is to ensure that the more difficult row is done first, followed by derotating the arteries and placing the front row [7]. Another modification is to place the bulldog clamps vertically instead of the classical horizontal placement. This will lead to two side-walls instead of the front-wall and back-wall [8]. The obvious theoretical advantage of this technique is that the rotation of the arteries is decreased only to 90° instead of the classical 180° rotation. This signifies the theoretical risk of intimal damage during the 180° rotation.

In addition, there are many other modifications that affect other aspects of the arterial anastomosis apart from the method and sequence of stitching such as the use of a microscope versus the use of surgical loups [5,9,10], modification of thread size, needle size, and others [1]. Finally, the timing of the anastomosis, such as arterial reperfusion or simultaneous arterial and portal perfusion, is sometimes claimed to have merits over the classical portal reperfusion [11].

In this article, we report on a modification for the back-wall-first arterial anastomosis. Changes can be summarized in three points. No twisting or rotation was applied to the arteries at all. Apart from the last three stitches, no hanging was applied to the threads as every stitch was tied once it was placed. Also, as far as possible, no bulldog clamps were placed on the donor side; if an intimal tear occurs at the bulldog site, it would be almost unsalvageable. The main advantages of these modifications are that they ensure that minimal manipulations are applied to the arteries, especially the donor artery, which decreases the theoretical risk of intimal injuries. The other presumed advantage is that it is a fast technique, as it in essence involves consecutive simple stitches that are tied immediately with no hanging to the thread-ends, which may be time-consuming. This decreases the ischemic time that is essential to the graft. The technique is specifically beneficial in circumstances when the donor side is too short and does not allow for placement of bulldog clamps and/or rotation. To elongate the donor artery, dissection of the artery has to be extended to the hilum, which is not always possible and carries the risk of intimal injury or devascularization to the biliary ducts [8]. One final advantage is that it is essentially the same technique used in the equally important biliary anastomosis, an anastomosis that is usually performed in a narrow place, with very short donor duct. Therefore, the operating surgeon is accustomed to the technique.

A similar technique that does not include rotation of the arteries was reported by Yamamoto *et al.* [12] in 17 patients who underwent either upper gastrointestinal surgeries or LDLT. They used the surgical microscope in their technique and they could not get rid of the bulldog clamps; interestingly, they used only eight stitches to complete the whole anastomosis. Okazaki *et al.* [13] developed a similar technique that does not include rotation of the arteries and used it only when it was difficult to turn over the graft artery. In their technique, they specifically used devised short (4 cm) sutures with double-armed needles that facilitated insertion of both needles from inside to the outside on both sides and also facilitated the tying due to its short length. In addition, they did not apply bulldog clamps on the donor side. This shows the benefits of this technique in difficult situations.

Probably the main drawback of the current technique is that it is relatively difficult to master and hence requires a longer learning curve, but once mastered, all the above-mentioned advantages exist.

Our results show that hepatic artery thrombosis occurred once in our series and in this case, it was unfortunately not salvageable, and the patient died eventually. This devastating catastrophe mandates that extreme care be exercised while selecting the position of every stitch, and the surgeon should be aware that the patient's life depends on this. The results of hepatic artery thrombosis in LDLT vary between series [1]. Nevertheless, some centers reported zero incidence of hepatic artery thrombosis [8,9].

## Conclusions

Here, we present a modification to hepatic arterial anastomosis in adult LDLT that has a low risk of hepatic artery thrombosis and is useful as a routine technique for anastomosis or can be one of the surgeon's tools in difficult situations.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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