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Review Article

Complex percutaneous biliary procedures: Review and contributions of a high volume team

Eduardo Houghton*

ABSTRACT

A comprehensive literature review was performed to evaluate the state of art and level of evidence of complex percutaneous biliary procedures and their safeness and effectiveness. Amidst those procedures, the review focused on techniques to achieve non-dilated biliary drainage, multiple self-expandable metallic stents, multiple plastic stents for the treatment of benign biliary strictures, simultaneous biliary and duodenal stent placement, rendezvous maneuvers, and use of magnets to treat biliary stenosis or even create new anastomosis with the jejunum or duodenum. A description of each technique and revision of literature provides useful tools for clinical practice decisions.

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Keywords: Biliary; Drainage; Percutaneous; Procedures; Stents

Introduction

Opacification of the biliary system was first reported in 1921 with direct puncture of the gallbladder. In 1953, Seldinger¹ described his technique that would be later the basis of almost any percutaneous procedure and vastly used in the percutaneous biliary drainage (PBD).

Decades later, the introduction of the thin flexible 22-gauge needle (Chiba needle) by Okuda in 1974 allowed performing the percutaneous cholangiography.² The next step in its evolution was the percutaneous transhepatic biliary drainage with catheter placement.

In the beginning, it was an external one leading to a gross loss of bile and electrolytes imbalance. Afterwards, Hoevels et al³ and Nakayama et al⁴ used a guidewire to negotiate across the bile duct stricture and place an internal-external catheter allowing the bile flow into the duodenum.

It was also in 1974 that Smith and Bartrum⁵ described the percutaneous aspiration of abscesses. Then, in 1977, Gronvall et al⁶ performed the first percutaneous fluid drainage guided with the US. Later, the basis of those techniques combined spread its use to the PBD,⁷ and a new era of more complex biliary drainage had begun.

The PBD is a safe procedure indicated in many situations.

Regarding malignant diseases, PBD can offer temporary preoperative decompression in some selected cases such as hilar obstructions, portal vein embolization, cholangitis, renal failure, severe jaundice,⁸ as well as definitive jaundice treatment by stent placement in non-resectable patients. Concerning benign diseases, PBD allows the treatment of bile duct stones, biliary stenosis, fistulas, and biliary leakage amid others. Its relative contraindications are few such as massive ascites, multiple intrahepatic obstructions and bleeding diathesis.⁹

It is essential to perform a detailed clinical history, a computed tomography (CT) scan or magnetic resonance imaging before the PBD. The information obtained permits the operator to define the bile duct anatomy, assess the presence of parenchymal atrophy and portal vein patency.¹⁰ Also, it is useful to assess the odds to achieve the PBD successfully and to properly inform the patients about it.

Literature Review Methodology

A comprehensive computer-aided literature search for complex percutaneous biliary procedures was performed from no initial date to September 2018 by using MEDLINE and EMBASE. The following medical subject heading terms were used in the searches: biliary tract surgical procedures, hepaticojejunostomy

DAICIM Foundation, Buenos Aires, Argentina

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* Corresponding author. DAICIM Foundation, University of Buenos Aires and Hospital B. Rivadavia, Austria 2435 PB E, Buenos Aires 1425, Argentina.

E-mail address: ehoughton26@icloud.com (E. Houghton). ORCID: <https://orcid.org/0000-0002-8234-8160>pISSN 2636-0004 eISSN 2636-0012 <https://doi.org/10.18528/ijgii180036>

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stricture, bile duct injury, percutaneous transhepatic biliary drainage, dilatation, stent, plastic stent, self-expandable metallic stent, malignant hilar biliary obstruction, revision, magnet, magnet compression anastomosis, choledochcholedochostomy, choledochenterostomy, choledochoduodenostomy, bilio-biliary anastomosis, biliary-enteric anastomosis.

All human case reports or studies fully published in English were included; abstracts only were excluded.

Techniques in Complex Biliary Drainage

Common steps and malignant diseases

The first step of the PBD is to perform a cholangiography with a Chiba needle guided with the US from the right or left side depending on the case. The correct evaluation of this first cholan-

Fig. 1. First assessment of the biliary tree. An anterior right sector joint with the left branches mimicking the hilar confluence that could lead to an incomplete biliary drainage.

Fig. 2. Access to the missing posterior right sector that allows now a complete biliary drainage.

giography is critical because otherwise can mislead an inadequate treatment as we can see in Fig. 1 and 2. In this case, an entire separated posterior right sector and an anterior right sector joint with the left branches mimicking the hilar confluence could lead the operator to believe achieving full drainage when is missing an entire sector.

A dilated biliary tree usually is accessible to opacify under the US or even under only x-ray in the right side but when bile ducts are not dilated, it could be a complicated procedure. In those cases, there are several possible ways to achieve the biliary duct. One is under the US, lead the Chiba needle close to the visible portal branches and then try to contrast the bile duct there (Fig. 3).¹¹ Stepping up, the common bile duct accessed by a direct puncture under ultrasound is a safe procedure that allows injecting contrast in the biliary tree and perform the first cholangiography. After that, it is more accessible to puncture the outer branches (Fig. 4). Harris et al¹² described a similar procedure using a retrograde passage of a 5-Fr catheter from a previous, remote percutaneous access site. Another option is to play only under x-ray a portogram and then withdraw a little bit the needle to opacify the biliary tree.¹¹ The gallbladder puncture and then injecting contrast in it to achieve an indirect cholangiography is a safe option.¹³⁻¹⁸ Kühn et al¹³ also described a CT guided puncture of the bile duct that safely allowed to acquire a cholangiography that enhanced the non-dilated biliary tree. Their technical success rate was 90% in patients with dilated bile ducts versus 81% in patients with non-dilated ducts, with no significant difference ($P = 0.36$). They found no complications rates difference between the dilated and non-dilated groups. On the other hand, Weber et al¹⁹ reported a 6.94% rate of procedure-related complications in patients with dilated versus 14.5% in non-dilated ones. The difference was statistically significant ($P = 0.022$). In a large study with 1,304 PBD included, the only independent risk factor for arterial related injuries was the non-dilated biliary status.²⁰

At last, the most extensive but retrospective study with 3,110 procedures included found non-significant difference between the enlarged and non-enlarged biliary tree regarding arterial bleeding complications.²¹ The last two studies have two limitations. They are retrospective studies and both only assessed the arterial bleeding complications leaving outside the equation the rest of the possible bleeding ones. In summary, no prospective studies back

Fig. 3. Thin biliary duct punctured by retrieving the Chiba needle.

sufficient strong level of evidence and recommendation grade concerning this topic.

In some cases of patients with hepaticojunostomy, an indirect cholangiography is viable by puncturing the Roux loop.²² Also, it is possible to treat the biliary stricture and even the lithiasis through this loop. The procedure consists of accessing the Roux loop bowel percutaneously under the US plus x-ray guidance. Surgical clips or prior CT images provide the information for the right site to access. Most of the authors use a 22-gauge Chiba needle to access the loop, then use an introduction set and through it, they negotiate the bowel with a 4-Fr catheter and a hydrophilic guidewire to access to the biliary tree and then dilate the stenosis with a balloon or remove the lithiasis with dormia baskets if indicated.^{23–31}

Several authors conclude that the PBD is a safe procedure even in a non-dilated biliary tree.^{16–18,22,32,33} Although it is safe, accordingly to the current guidelines available, there is a difference in the success rates expected for both percutaneous transhepatic

Fig. 4. Direct puncture of the common bile duct.

Fig. 5. A guidewire advanced to the distal common bile duct and a second one passes towards the contralateral branch.

cholangiography and percutaneous transhepatic biliary drainage concerning the presence or absence of dilation in the biliary tree.^{9–34} In non-dilated biliary ducts, the success rate expected is 95% in dilated ducts against 65% in non-dilated. The cannulation success rates should be over 95% in dilated ducts against 70% in non-dilated ones.

Once the biliary tree is accessed, the next step is to negotiate the stenosis and leave a catheter. It is commonly effortless when the stenosis is unique and distal, but not when it is dissociating the right and left main branches or even the right sectors from each other. In those cases, placing multiple catheters can solve the problem with the disadvantage of needing more entry points. Therefore more punctures and consequently more bleeding risk as we could establish in a prospective study of 150 cases of PBDs; number of punctures (threshold set in > 5): the odds ratio (OR) was 2.8495 (95% confidence interval [CI], 1.0771–7.5389) and number of drains (threshold set in > 2): OR was 4.1282 (95% CI, 1.4234–11.9730) (Houghton EJ et al; unpublished data). Therefore, Shlansky-Goldberg et al³⁵ described a technique that solves the equation without increasing the risk called articulated catheters.

Negotiated the stenosis, a guidewire is advanced to the distal common bile duct and a second guidewire passes towards the contralateral branch (Fig. 5).

Meanwhile, on the table, we cut a multipurpose catheter and attach a thread to the distal part of it that will be used to withdraw it in the future (Fig. 6). Over the side to side guidewire, the cut-multipurpose catheter is advanced using the proximal part as a pusher. After that, the guidewire that goes distally allows placing a biliary catheter (Fig. 7).

Once the cholangitis passes or jaundice decreases, the next step is to remove the catheters, first the biliary and then the cut-multipurpose by pulling from the thread. After done this, two biliary stents in a “T” shape configuration is an excellent option to achieve long-term and more comfortable patency of the biliary tree (Fig. 8).

In cases where the two right sectors are divided, a complicated but feasible procedure is useful to set in place several stents. For this procedure, called stents in “Lily” shape because of its remembrance of flowers in a cup, it is necessary to have access to the left lobe, the anterior and posterior sector separately. Then, three guidewires negotiate the stenosis and pass to the duodenum. One of them will carry a 120 mm biliary stent that will go trans-papillary. A 10 mm balloon dilates it. Afterwards, the three guidewires go inside the previous 120 mm stent allowing the entrance of three 8 mm biliary stents (Fig. 9).³⁶

There is controversy as to what volume of the liver is better to drain in malignant obstruction. Although some authors concluded that partial liver drainage has the same quality of life as the complete liver drainage and same survival rates,^{37–39} they also proved that those patients with persistent jaundice (bilirubin levels above 4 mg/dL) have worst quality of life assessment, even fewer patency rates and poorer survival rates and fewer odds to complete palliative chemotherapies. Besides, the value of these results

Fig. 6. Preparation of articulated catheters.

Fig. 7. Articulated percutaneous biliary drainage.

Fig. 8. "T" shape biliary stents.

could not be strong enough as they could not achieve meaningful statistical comparison in patients with lesion types Bismuth II to IV treated with unilateral versus bilateral stenting because of the small number of patients.

The study conducted by Bruntzos et al³⁹ concluded that the patency rates did not differ between the hilar and non-hilar tumors ($P = 0.565$) and did not depend on the level of obstruction on the Bismuth classification ($P = 0.462$).

On the other hand, a fascinating study performed by Inal et al⁴⁰ evaluated several variables amid one stent placement, two stents in a "T" shape and a "Y" shape. They concluded that there was no statistically significant difference among stent configurations in Bismuth type II, III, and IV obstructions. The patency rate was not statistically significant in Bismuth type II and III obstructions, but was significantly higher in the "Y" configuration in Bismuth type IV obstructions. Other authors also found similar results in patients with type IV bismuth strictures: complete biliary drainage has superior patency rates, better clinical outcomes, and survival rates.⁴¹ Regarding this topic, more prospective and com-

Fig. 9. "Lily" shape biliary stents.

parative studies to achieve strong recommendation levels seems to be necessary.

Sometimes, the tumor compromises not only the biliary duct but also the duodenum. For those patients, a duodenal stent placed per-orally,⁴²⁻⁵⁰ through a percutaneous gastrostomy⁵¹ or through the biliary access at the same time as the biliary stent placement is a good option.⁵²⁻⁵⁴ Regarding the biliary access, there are two possible situations: the duodenal stenosis is distal to the papilla or proximal. In the first one, it is effortless to pass two guidewires. Over one of them will go the biliary stent and over the second one the duodenal stent (Fig. 10). However, when the duodenal obstruction is proximal to the papilla, it is more difficult to achieve the stent implantation. For this scenario, it is necessary to pass a guidewire from the biliary tree to the distal part of the duodenum and a second guidewire reversely to the pre-stenotic part of the duodenum or stomach depending on how proximal the stenosis goes. Then, the delivery of the duodenal stent (or colonic if the duodenal stent has not proximal and distal cups) advances over the guidewire and the delivery system of the biliary stent over the distal guidewire. Once both delivery systems achieve their final position, both deployments take place. Placing both delivery systems after opening any of any of them, allows the biliary stent to stay outside the bowel transit (Fig. 11).

In a recent retrospective study published by Bulut et al,⁵¹ they have treated 53 patients using uncovered self-expandable metallic stents of 20 to 25 mm in diameter and 6 to 12 cm in length for gastric outlet obstructions by the transoral approach in 46 patients (86.7%), trans-gastric approach in six patients (11.3%), and transhepatic approach in one patient (1.8%). Of those 53 patients, 21 have both biliary a duodenal stents: in seven patients it was simultaneously, and in fourteen it was one after the other. Their success rate with those patients was 100%.

Concerning the transoral approach, the technique consists of passing a hydrophilic guidewire through the patient's mouth, and manipulate it with a 5-Fr catheter to negotiate the stenosis. It is useful to change the hydrophilic wire for a stiffer one like the Amplatz (Boston Scientific) 260 cm wire to avoid having a big

Fig. 10. Transhepatic duodenal stent placement. (A) Simple x-ray where biliary drainage is observed as well as dilated stomach due to duodenal obstruction. (B) Yellow circle shows the duodenal obstruction. (C) Duodenal stent delivery placement. (D) Yellow circle shows the duodenal stent completely delivered.

Fig. 11. Both biliary and duodenal stents.

loop in the stomach cavity. Sometimes to prevent this to happen, a sizeable vascular sheath gives stiffness and allows the delivery stent system to advance across the stricture without any problems.

Concerning the trans-gastric approach, the technique is quite similar, but the only difference is that the entry point of the delivery system of the duodenal stent is through a percutaneous gastrotomy. This approach is indicated when the transoral approach has failed before. The placement of both biliary and duodenal stents should follow the same sequence described above.

Sometimes, patients could have a previous hepaticojejunostomy, and a recidivated tumor can also compromise it. There is

no extra difficulty in setting biliary stents in those cases but when the efferent loop bowel is compromised things could become more challenging.⁵¹ For these situations, a guidewire should advance and negotiate first the hepaticojejunostomy stricture. Then, with a larger catheter do the same with the efferent loop stricture. Now the delivery system of a duodenal stent goes forward and take place over the stenosis. Once deployed, the delivery of the biliary stent can get inside the previous expanded duodenal stent and therefore reaches its final position. If the efferent loop stricture is far away from the hepaticojejunostomy, it is not necessary to place the biliary stent inside the duodenal one.

Most of the articles yielded the consensus that simultaneous biliary and duodenal stenting is a safe and effective procedure.^{51–54}

Benign Diseases

Regarding benign diseases that could need a complicated biliary procedure, we find the postoperative biliary strictures as well as the postoperative hepaticojejunostomy strictures. The first line of treatment is the balloon dilation first described by Molnar and Stockum⁵⁵ in 1978, a simple practice with a success rate surrounding 60% depending on the series.^{56–63} The balloon dilation procedure is not a very complicated one. Over the previous biliary drainage, the guide wire advances and the withdraw of the catheter takes places. Afterwards, a 10 mm over the wire balloon moves forwards across the stricture and dilates it. A new biliary catheter will allow the bile to flow again.

Usually, if the stricture persists after three dilation sessions, dilation treatment is considered unsuccessful. Therefore, alternative therapies begin to play an import role.^{64,65}

Amid those other therapies, is the sustain dilation. It is a procedure developed by Costamagna et al^{66,67} performed endoscopically. It consists of placement of an increasing number of plastic

stents until complete morphologic disappearance of the stricture and left there for several months.⁶⁶⁻⁷⁰ This sustain dilation avoids the constriction generated by the inflammatory response in the restraint. Authors reported that 80% of their patients were in good clinical condition, with liver function test and US results within the normal range after a mean of 13.6 years.⁶⁶

Additionally, a recent meta-analysis concluded that the endoscopic treatment had the same long-term patency as surgical treatments and would be the first line treatment due to the lower risk of complications, easy implementation, and cost-effectiveness.⁷¹ There is still controversy between the use of a fully covered metallic stent and this endoscopic technique of multiples plastic stents. A recent metanalysis concluded that both have the same efficacy but with a slight advantage in favour of the former due to the fewer procedures needed to achieve the dilation.⁷²⁻⁸⁰

It is also possible to do this procedure percutaneously with similar success rates as its endoscopic pair (Giménez et al; unpublished data). With 18 cases treated with this novel approach, the group still need more examples and follow-up to compare their results with the endoscopic ones. However, the actual results are promising with 24-month average of follow-up and 83% of clinical success without recurrence (Fig. 12).

The technique has common points with the articulated drainage above described. It begins with a PBD, and then a guidewire negotiates the stenosis. Then, a balloon dilation that will enable the place for the multiple catheters proceeds. Afterwards, an introducer advances over the guidewire beyond the stricture allowing several guidewires (as many as catheters needed to dilate the stenosis completely) to negotiate the stenosis inside it. Over one of them, a biliary catheter goes and over the others, the cut-multipurpose catheters placed one at a time. The thread attached enables to withdraw them once the four-month period of treatment passes.

For those patients in whom either endoscopic and percutaneous treatment had failed, the next step would be the combined rendezvous technique.⁸¹⁻⁸⁴ This rendezvous is a collaboration between the endoscopists and the interventional radiologists. The point of the meeting could be extraluminal, for example inside a bile collection cavity, or intraluminal: inside the bile duct or even between the bile duct and the duodenum. The most interesting one is the former. In case of a bile duct injury that leads to a bile fluid collection that separates both the proximal and distal ends

of the injured bile duct, a guide wire inserted transhepatically and advanced through this collection allows a loop or dormia basket from the endoscopic approach to snare the wire and externalize it into the duodenum. Now, the guide wire goes from the proximal portion of the bile duct, passing through the fluid collection and back into the distal portion of the bile duct. Over this guide wire, a biliary catheter recanalizes the biliary tract. The next stage should be the sustain dilation that sometimes takes place simultaneously.

The same basis allows performing this type of treatment entirely by a percutaneous approach (Fig. 13-17). In this case, a multipurpose catheter inside a bile collection permits to externalize the guide wire inserted transhepatically. Then, a biliary introducer conducted over this guide wire allowed to negotiate the space and get inside the distal portion of the biliary duct. The guide wire loop between the proximal and distal part of the bile duct could be undone using a peel-away sheath. Finally, a biliary catheter assembled the bile duct.

Fig. 13. Section of the posterior right biliary duct.

Fig. 12. Bilateral sustain dilation.

Fig. 14. A guidewire is entering the multipurpose catheter placed inside the bile collection.

Fig. 15. A guidewire is coming out through the fistula tract.

Fig. 16. A guidewire is re-entering to the distal common bile duct.

There is limited data regarding the rendezvous procedure. It mostly consists of case reports and small series. Schreuder et al⁸¹ treated 44 patients with the rendezvous technique. They reported a 94% initial success rate in patients with complex biliary duct injuries following laparoscopic cholecystectomy, no 90-day mortality, and low morbidity (18% of adverse events). After a median follow-up of 40 months, they described a long-term surgery-free and stent-free success rate of 55%.

Fiocca et al⁸⁵ reported even better results, 100% technical success rate and long-term success rate of 82%, with low morbidity, in a series of 22 patients with complete transection of the common bile duct.

Most of the authors conclude that with low morbidity and mortality, it should be the next step in management before moving further to surgery. Besides, the rendezvous can act as a bridge to surgery in those refractory cases. The actual data only support a low grade of evidence (SIGN 3) but a promising one. More prospective trials are needed to upgrade the grade of recommendation.

Concerning more complex biliary injuries, they could be sections or even resections. However, not only the biliary injuries

Fig. 17. A biliary drainage is reconstructing the biliary tree.

could feed complicated biliary procedures, but also some issues with the hepaticojejunostomy as complete dehiscence. For the last particular situation, a combined method performed entirely under percutaneous approach can create new hepaticojejunostomy.⁸⁶ The technique described by Mansueto et al⁸⁶ started with the puncture of the afferent loop. Then a guide wire advanced, and over it, a sheath was left in the jejunum. A second sheath acceded to the biliary tree and contrasted it. The trocar stylet of transjugular liver access set advanced through the jejunum sheath and advanced puncturing the jejunum wall and the bile duct. Afterwards, they pushed a guide wire into the bile duct caught by a snare inserted through the transhepatic sheath and pulled outside the patient. Using this wire, they left a biliary catheter creating the new anastomosis.

For the section and even resections of the bile duct and for those cases of bilio-biliary or bilio-enteric anastomosis strictures in which a guide wire could not pass through them, combined therapy with magnets, developed by Yamanouchi et al,⁸⁷ can reconstruct the biliary tract or the anastomosis.^{87–105}

It consists of the placement of two magnets, one from the distal part of the bile duct under endoscopic approach and the other from the upper portion of the injured bile duct under percutaneous access. Once the two magnets attract themselves, they generate ischemia in the interposed tissue between the upper portion and the distal portion of the bile duct. Lately, both magnets create a new communication in the injured bile duct, and the scar that they left behind serves to create continuity. Afterwards, magnet removal takes place, and a catheter, multiples plastic stents or a fully covered self-expandable metal stent maintain the new communication diameter and avoid the scar retraction. Finally, the treatment ends with the removal of the devices.

This fantastic but complicated combined procedure could also generate a new bilio-enteric anastomosis with similar steps.^{95,96} Jang et al¹⁰⁵ described in a recent report, 42 bilioenteric procedures, eight due to benign strictures and the rest for malignant invasion. In the latter cases, a new anastomosis between the biliary tree and the duodenum created by the magnets was the path to clear the bile flow.

The weakest part of this approach is its total procedure time ranging from 15 to 22 days.⁹⁶ This time to magnet removal after successful approximation depends on three factors: (1) the dis-

tance between the two magnets, (2) the strength of them, and (3) the histological situation close to the obstruction.¹⁰⁴ Therefore, the bilio-biliary anastomosis requires more time to achieve the patency than the bilio-enteric one. Regarding this, the use of the echoendoscopic lumen-apposing covered self-expanding metal stents for the anastomosis creation seems to be timeless, but its analysis exceeds the aim of this review.

Concerning the use of magnets to treat benign strictures, although the feasibility and safety of it have been experimentally and clinically verified in cases of biliobiliary and bilio-enteric anastomosis,¹⁰⁵ the available data is not enough to generate a good level of recommendation. More randomized trials regarding the different types of procedures appear to be required to compare those with traditional surgery.

Conclusions

Complex percutaneous biliary procedures achieve almost the same goal of conventional surgery in most of the proceedings with a less invasive treatment, less morbidity and mortality. With the new technologies available and the improvement of them, probably in the future they will become more effortless and will replace traditional operation as we know it nowadays. More prospective, randomized trials are needed to improve the strength of the level of evidence and grade of recommendation regarding these percutaneous complex biliary procedures.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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