TYPE OF ARTICLE: Case Series

TITLE: Novel, Integrated Rapid Exchange Pre-mounted, Single-Stent, Self-Detaching Delivery System for Biliary Stent Placement: Case Series of First-in-Human Experience.

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Short Running Title: Novel Rapid Exchange Stent Delivery System for Biliary Stent Placement

TITLE: Novel, Integrated, Rapid Exchange, Pre-mounted, Single Stent Self-Detaching Delivery System for Biliary Stent Placement: Case Series of First-in-Human Experience.

ABSTRACT

INTRODUCTION

Current commercially available biliary stent delivery systems are limited by a loss of guidewire positioning after stent delivery, predominantly seen in cases with difficult ductal access requiring additional intervention following an index stent placement. A novel biliary stent delivery system, with integrated rapid exchange and self-detaching mechanism, has been developed to address these limitations. The primary objectives were to test this delivery system in human subjects for the first time to assess the success of the stent delivery, the localization of the stent within the bile ducts and post-delivery wire in-situ fixation. Secondary objectives included the ability of the device to reach its location within the bile duct, placement and location of the stent.

CASE SERIES

A series of patients undergoing biliary stent procedures for biliary obstruction due to gallstones (n=3) and post-cholecystectomy benign stricture (n=1) is described utilizing the novel stent delivery system.

The system was deployed with relative ease with all stents successfully placed into the required position without any wire dislocation. The delivery system was rated as easy-to-use, and appears to remain in-situ staying without migration following index stent delivery.

CONCLUSION

The novel single stent delivery system was successfully deployed in the first-in-human case experience of four patients requiring stenting in the region of the common bile duct. The stents were successfully placed in-situ, with no procedural complications, enhancing procedural simplicity while ensuring secure and accurate ductal access. Further case experience is needed to build on the findings of this case series.

Keywords: Biliary Stent, Pre-mounted, Novel Delivery System, In-situ Wire

TITLE: Novel integrated Rapid Exchange, Pre-Mounted, Single Self-Detaching Delivery System for Biliary Stent Placement: Case Series of First-in-Human Experience.

INTRODUCTION

Patients presenting with common indications including bile duct obstruction, leaks, etc. require the insertion of a stent to establish patency of biliary drainage. [1,2] Limitations of current biliary stent delivery systems include stent migration, tissue trauma due to tight lumen strictures, and difficult ductal access. [2,3,4,5,6] Guidewire-assisted access is thought to assist with the success of biliary cannulation with a small diameter guidewire being able to pass more easily through the small diameter opening of the common bile duct.[7] The need for prevention of complications and providing cost-effective care through an easily managed procedure is clear. [1,2].

A pre-loaded single stent delivery system has been developed to overcome some of these limitations. The S-Path (invented by ENDOGI, Nazareth, Israel) is a novel stent delivery system which is preloaded with a rapid exchange mechanism to facilitate user-friendly guidewire loading. The Pre-mounted stent operating via a one-system pass has been designed for secure and accurate guidewire positioning and placement, with the added advantage of procedural simplicity and has a self-detaching feature.

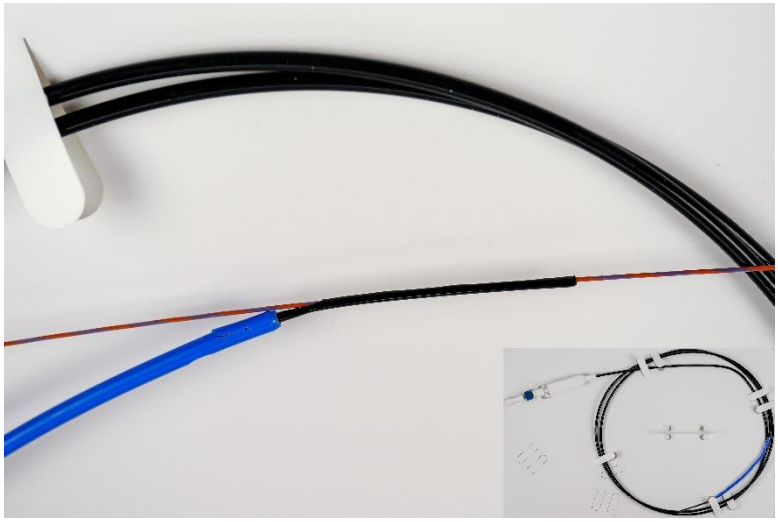

Figure 1 : Delivery system with tip details an guidewire in place

The single stent delivery system (S-Path) has undergone proof of concept and we report on a limited case series of four patients where the S-path was tested for the first time in human subjects.

CASE SERIES

The primary objectives of this case series were to document the first-in-human experience with the stent delivery system. This included utilizing the technology in human patients, verifying the location of the stent within the bile duct, and maintaining the guidewire in place after stent placement. Secondary objectives included the ability of the stent to reach its required location within the bile duct, as well as verifying its positioning in-situ.

Case 1

An 80-yr old female patient, presented with almost complete bile duct obstruction due to biliary stones, diagnosed by abdominal US. An ERCP was performed. Two bile duct stones were identified and successfully removed by a stone-extraction balloon. (Figure 2).

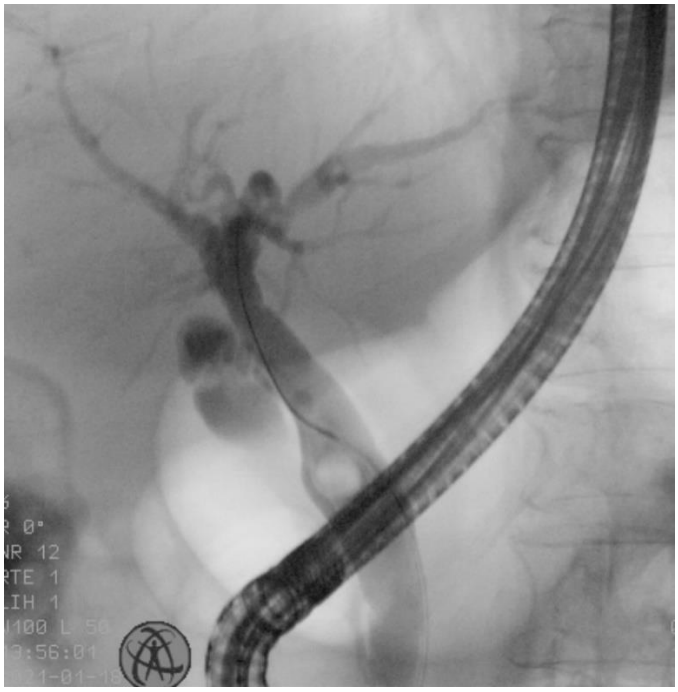

Figure 2: ERCP: common bile duct filling defect (stone). A Significantly dilated cystic duct was identified without clearly visible stones.

(Figure 3).

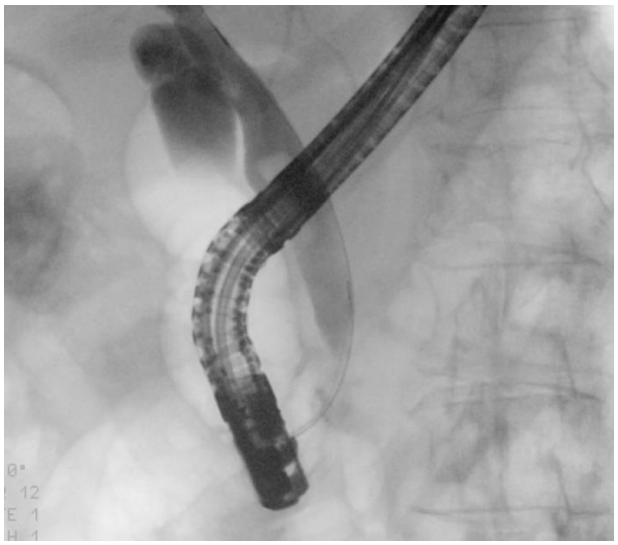

Figure 3: Marked dilation of the cystic duct with one common bile duct stone still remaining.

Following these findings, we elected to proceed to prophylactic stenting until the patient could be scheduled for cholecystectomy. The wire was repositioned. After a few minutes the novel single stent rapid exchange system was mounted over the wire, inserted proximally into the scope and exited at the distal end. The delivery system was positioned, and the 10 F diam 10 cm length stent placed in situ, with the wire remaining in place following stent delivery. (Figure 9)

Figure 4: Guidewire seen running parallel to the stent on the right immediately after the stent was delivered. As with the previously reported cases, the delivery system was rated as easy to use by both the nurse and the endoscopist.

Case 2

A 25-yr old female postpartum patient was admitted to the surgical department with biliary pain, jaundice and common bile duct dilation with multiple gall bladder stones, diagnosed by ultrasound (US). After 24 hours observation without clinical and laboratory improvement, an Endoscopic retrograde cholangio-pancreatography (ERCP) was performed. A bulging papilla was found During the procedure. Following successful selective biliary sphincterotomy a small, impacted stone dropped out from the papilla, a stone-extracting balloon then was passed and the additional small stone was removed from the common bile duct. Due to the large number of small stones into the gall bladder and relatively small sphincterotomy, we decided to insert a prophylactic biliary stenting system until the patient could be scheduled for cholecystectomy. The position of the guidewire was adjusted and the ENDOGI system was mounted onto the guidewire.

The ENDOGI system was inserted into the scope and exited the other end. When we tried to insert the ENDOGI system, we encountered resistance. The tip was not registering as radio-opaque, and it was unclear whether the difficulty was due to un detachment of the catheter tip or tissue resistance. Although the system has demonstrated resilience and strength, there was a concern that applying undue force would result in subsequent tissue damage. For the above reasons, the procedure was interrupted and the ENDOGI system inspected for any missing parts or damage. Following deliberation, it was decided to re-initiate the procedure with a new ENDOGI system in the event that the first system was

damaged. The ENDOGI system was inserted with relative ease and the 10 F diam 10 cm length stent successfully placed in situ, with the wire remaining in place following the stent delivery. The procedure was successfully completed (Figure 6).

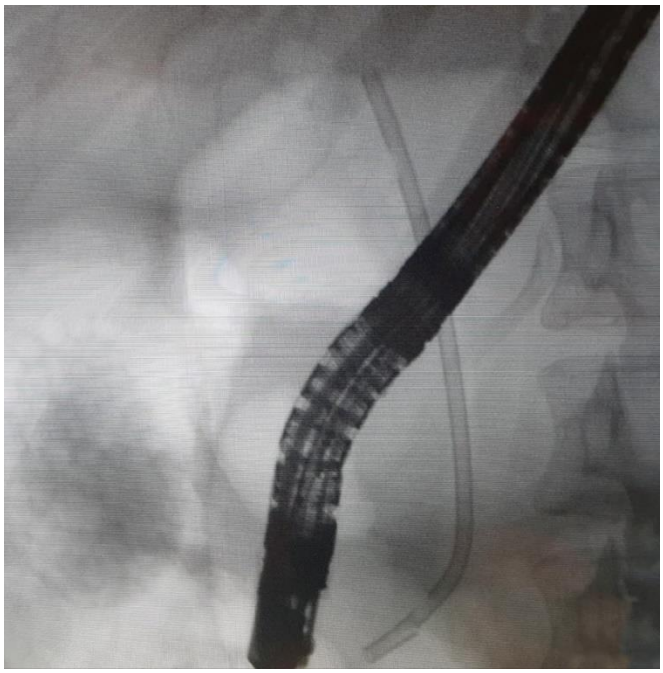

Figure 5: Stent in place at the end of the procedure.

Once again, the nurse was extremely satisfied with the procedural ease, which allowed for rapid exchange. The endoscopist was also highly satisfied with the procedural ease of the delivery system, needing to thread the wire just a few centimeters.

Case 3

A 40-yr old female patient, with a known history of bile duct stones and two previous lithotripsy procedures, presented for re-treatment (Figure 2).

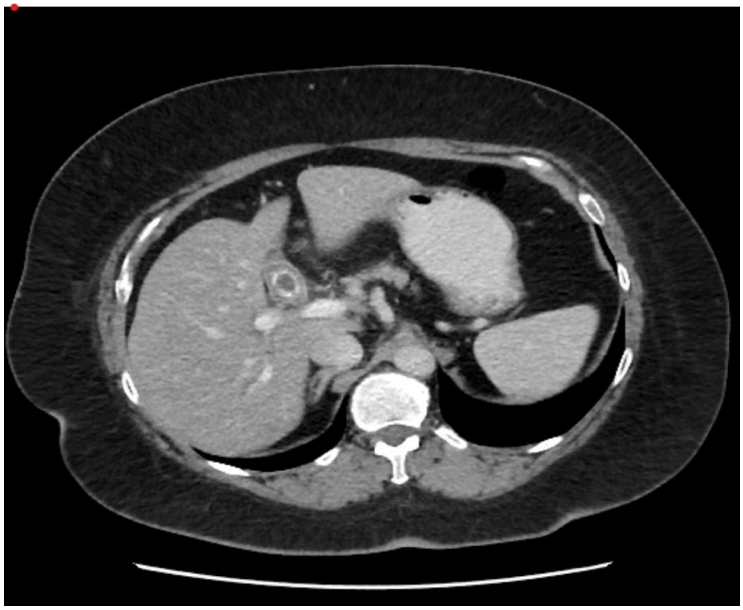

Figure 6: CT scan shows large stone within the bile duct.

The patient was previously treated with a SpyGlass DS system (Boston Scientific [9]) to guide visualization during the electrohydraulic lithotripsy procedure. A 10 mm diam 4 cm length fully covered metallic stent and 9 cm length 10 F diameter stent were inserted and the patient was discharged. The patient re-presented for further stone lithotripsy utilizing the SpyGlass DS System (Figure 7).

Figure 7: Remaining large, impacted stone within the bile duct. The first ERCP image following prior stents have been removed.

Following a one and half hour procedure, the huge biliary stone was complete fragmentated and removed. Due to the fact that there were multiple residual small stone particles, within into the biliary tree, we decided to insert multiple stents to avoid stent migration within the large bile duct diameter. A Cook 10 F stent was placed in situ and discharged. The first successful deployment of the ENDOGI single system was utilized with 10 French stent with an average length of 110 mm. The wire placement was established after a few minutes and the single stent system mounted over the wire. The ENDOGI system was inserted into the scope and exited the end. A difficult angle was identified between the scope and the first stent within the bile ducts, after some deliberation, it was decided to introduce the ENDOGI system. The system was introduced applying

an average force, with the stent successfully placed and with the wire remaining in-situ with no subsequent displacement (Figure 4).

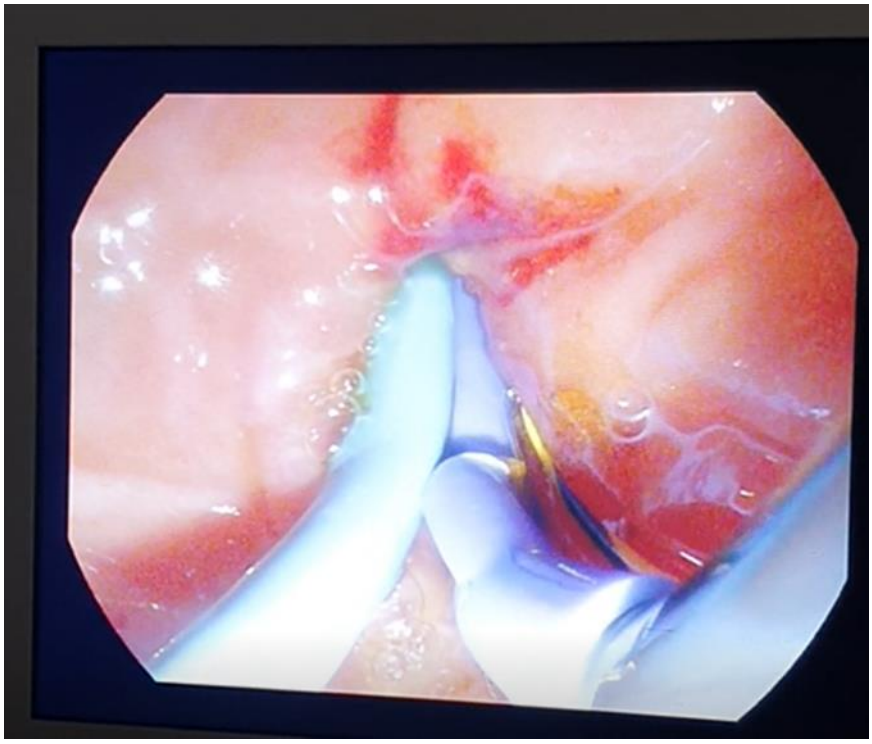

Figure 8: Guidewire seen running parallel to the stent after second stent placement.

The procedure was successfully completed (Figure 9).

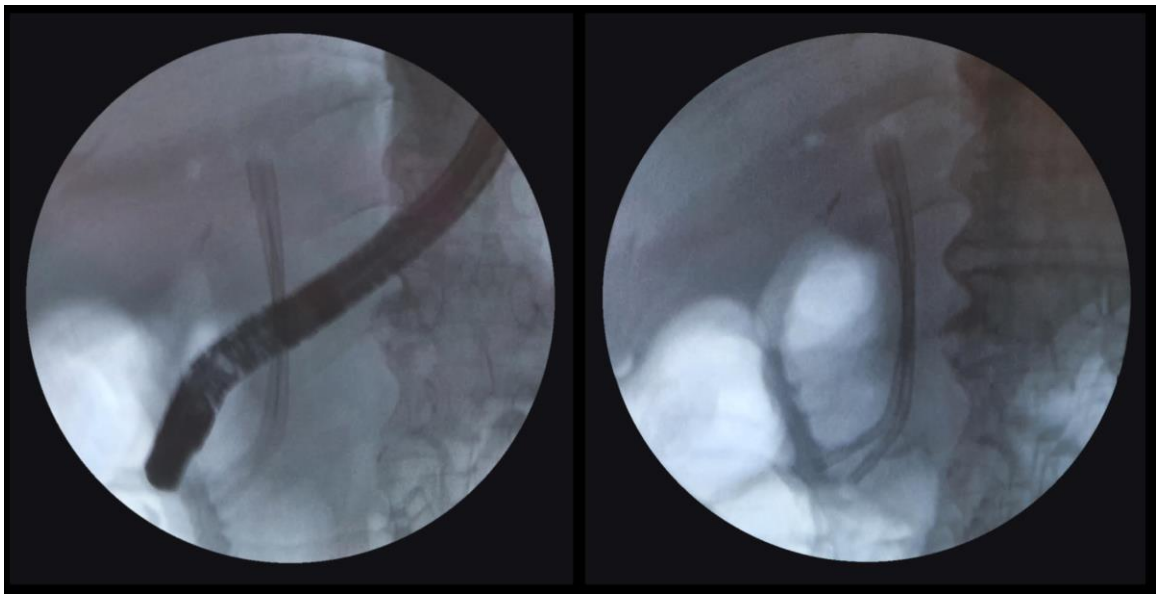

Figure 9: Two stents in place at the finishing of the procedure.

The nurse was extremely satisfied with the procedural ease, which allowed for rapid exchange. The endoscopist was also highly satisfied with the procedural ease of the delivery system, needing to thread the wire just a few centimeters. The patient was admitted for observation without immediate complications and discharged the following day in good clinical condition and with normal laboratory results.

Case 4

A 50-yr old female patient, who was post uncomplicated laparoscopic cholecystectomy, presented with a tight common bile duct stricture identified by Magnetic resonance cholangiopancreatography (MRCP). A diagnostic and therapeutic ERCP was done. A poorly defined short stricture was found, and brush cytology was performed to exclude malignancy.

The novel single stent rapid exchange system was inserted proximally into the scope and exited through the distal end. The delivery system was positioned, and the stent placed in-situ with successful completion of the procedure. (Figure 10)

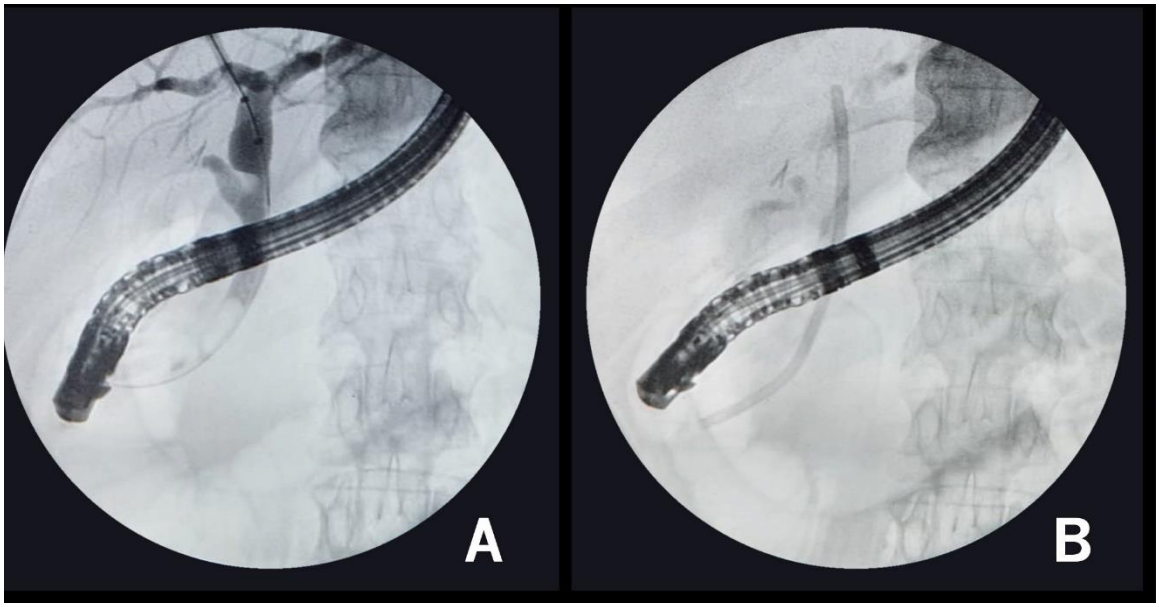

Figure 10 A: A stricture can be seen at the origin of the cystic duct insertion.

B: The stent in situ after placement and removal of the wire.

This same patient, presented over two months later for a repeat procedure.

Brushing cytology results were negative for malignancy and the patient was clinically well. However, due to the possibility of a false negative cytology result, and in accordance with the recommended standard practice in cases of an undefined bile duct stricture we decided to proceed to a second ERCP procedure with the SpyGlass DS System (Figure 11).

Figure 11: The SPY GLASS system is inserted into the bile duct at the level of the stricture.

At the time of the procedure, the stent was in its original anatomical location with no signs of migration. The removal was uneventful, and the stent was fully intact with no demonstrable blockage. SPY GLASS cholangioscopy identified a benign fibrotic stricture. Following a biopsy, it was decided to proceed to endoscopic treatment: gradable dilation by multiple stent insertion, starting with two plastic stents.

We decided to try to insert a new ENDO GI multiple stent placement system. During insertion, the guidewire was pushed too deep which created a loop at the distal end. The first 10 F diam 10 cm length stent was released, however, due to the distal looping of the guidewire, it could not be optimally positioned and therefore it was pulled back. The multi-stent delivery system was removed with the second stent locked into the system. The guidewire was reinserted, deploying the novel rapid exchange single stent system. The second 10 F diam 10 cm length stent was released and successfully implanted. Once again, the wire remained in place following stent delivery and the position and orientation of the wire were maintained (Figure 12).

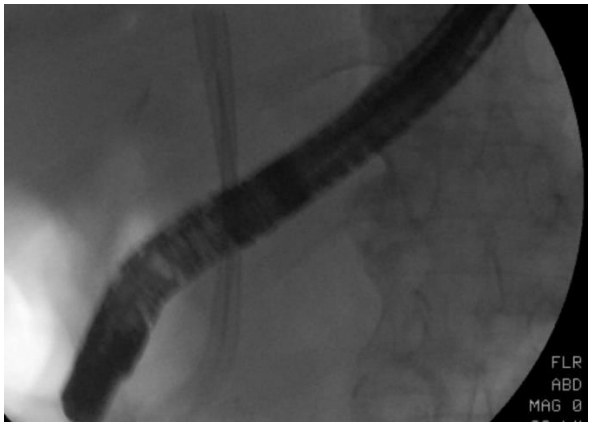

Figure 12: Two stents in place at the end of the procedure.

DISCUSSION

In these 4 cases (5 stents) experience we were unable to identify any significant drawbacks associated with the novel stent delivery system. The availability of an easy-to-use, rapidly deployed delivery system that ensures accurate placement and provides good ductal access, combined with procedural simplicity is somewhat lacking. The S-Path (developed by EndoGI; Nazareth) was designed to address these procedural shortcomings. We describe a series of 4 patients undergoing biliary stent procedures utilizing the novel rapid exchange single stent biliary delivery system. Patients who presented with near to complete biliary obstruction due to gallstones (n=3), post-cholecystectomy stricture (n=1) requiring stent insertion were included in this preliminary case-series.

The S-Path system was deployed with relative ease with all stents successfully implanted in-situ without migration. The delivery system was rated as easy-to-use, ready for immediate use without the need for charging or lengthy over-the -wire threading. In all four cases, the ease of use and the short distance required to deploy the system, which only needed to be threaded over the wire for a few centimeters was evident. This contrasts with other stent delivery systems that require deeper wire insertion and management.

In all four cases, the stent was successfully implanted and remained in-situ. In addition, we would like to highlight the benefits of the wire remaining in place following stent release and removal of the catheter.. The stent delivery system demonstrated a favorable safety profile, there were no immediate complications following the procedures, and patients did not return with late complications

following the procedures. In the case of patient 4, who presented for a repeat procedure after 8 weeks, and the stent removed was shown to be fully intact and in situ. The rapid exchange pre mounted stent fixes the wire in situ and allows for shortening of the procedure time, when multiple stent insertion is required.

To our knowledge this is the first biliary stent system that has a rapid exchange, pre-mounted and self-detaching mechanism. The benefits of this novel system include procedural simplicity and decreased time to deploy stents, and, most importantly allow for multiple stent insertion on the same wire, without any additional intervention. As is evident from the literature, extended time taken for ERCP procedures due to difficulties with ductal access or procedural issues with stent delivery systems, has been directly correlated with an increased risk of post ERCP pancreatitis (PEP) [3,4] cardiopulmonary complications, as well as being associated with increased hospitalizations and costs [10,11].

CONCLUSION

The novel rapid exchange self-detaching single stent delivery system was successfully deployed in the first-in-human case experience of four patients requiring stenting in the region of the common bile duct. The stents were successfully placed in-situ, and the device was rated favorably by both the endoscopist and nursing assistant. The stent delivery system was found to enhance procedural simplicity while ensuring secure and accurate ductal access without any post procedural complications, highlighting its potential benefit in

increasing the procedural ease and safety, reducing the time and cost associated with biliary stenting. Further case experience is needed to build on the findings of this case series.

CONFLICT OF INTEREST

The author is EndoGI consultant

AUTHOR'S CONTRIBUTIONS

Author A

Conception of the work, acquisition, analysis and interpretation of the data, drafting the work, revising the work for intellectual content, final approval of version to be published. The author agrees to be
accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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Abbreviations: List all abbreviations & full terms

CT- Computerized Tomography

DS- Delivery System

ERCP- Endoscopic retrograde cholangio-pancreatography

MRCP - Magnetic resonance cholangiopancreatography

F-French

PEP- post ERCP pancreatitis