Curriculum matrix development for a hepato-pancreato-biliary robotic surgery fellowship

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Summary

Robotic surgery is being increasingly used for complex benign and malignant hepato-pancreato-biliary (HPB) cases. As use of robotics increases, fellowships to excel in complex robotic procedures will be sought after. With this dedicated training, attending surgeon positions can be obtained that can incorporate and teach this skill set. Unfortunately, there are no evidence-based approaches for constructing a curriculum for an HPB robotic surgery fellowship. This paper describes a technique to develop a structured curriculum to ensure competence and fulfil the learning and practice needs for robotic HPB fellows.

The robotic platform in hepato-pancreato-biliary (HPB) disease is starting to gain popularity owing to the advantages it technically can offer over conventional and open techniques. Robotic surgery overcomes laparoscopic limitations through optical magnification, 3-D depth perception, augmented instrument articulation, and greater precision with suture targeting.[1] These benefits have brought robotic surgery to the forefront as an attractive and, more importantly, inclusive opportunity for a minimally invasive approach to complex and benign HPB disease. With studies correlating technical performance and surgeon volume with postoperative outcomes, the importance of effective training is paramount.[2,3] Unfortunately, even new graduates are lacking comfort and skill in the robotic arena owing to considerable disparities across education and technical experience of robotic exposure during training. While there have been improvements over the last decade in regards to resident participation in robotic cases, formal curricula remain variable and lacking.[4,5] And, unfortunately, these curricula often limit participation to mainly observation, resulting in inexperienced graduates without the appropriate skill set to operate safely while unaccompanied.[6] As a consequence, skill development in this area among attending surgeons depends on the needs of the professional community and surgical societies. As such, a role for robotic fellowships has emerged for comprehensive and formalized training. With no current evidence-based approaches for constructing a curriculum for an HPB robotic surgery fellowship, we describe here our technique in creating a structured curriculum at the Carolinas Medical Center, Atrium Health.

Our HPB robotic surgery fellowship is a 12-month commitment that lies between a postgraduate education level and continuing professional development. As such, the curriculum is customized to meet individual needs and is designed to ensure fellows achieve a minimum level of competence, professionalism and patient safety[7] (Table 1). Thus, there are 2 proposed pathways: pure clinical, and clinical and research.

The pathway model addresses content overload and allows each to concentrate on modules or competencies that may be more important in future practice. The essential technical competencies are incorporated

Table 1. Contextual information about the HPB robotic surgery fellowship curriculum

Title	Hepato-pancreato-biliary (HPB) robotic surgery fellowship
Target audience	The HPB robotic surgery fellowship is offered to physicians who completed an official training in general surgery and an AHPBA-accredited HPB surgery fellowship. Furthermore, they should be board-eligible or -certified either by the American Board of Surgery (ABS) or the Royal College of Surgeons (RCS) or the European Board of Surgery (EBS). This is a 12-month fellowship. One fellow per year will be trained.
Summary of the curriculum rationale	For "customization" purposes, at the beginning of this 12-month HPB robotic surgery fellowship, fellows should chose which of the following pathways to pursue: 1) Pure clinical 2) Clinical and research The curriculum structure and content for each fellow is built according to the chosen pathway.
Aim of the curriculum	At the conclusion of the HPB robotic surgery fellowship, the fellow will be able to: 1) Perform robotically HPB-relevant operative procedures 2) Provide state-of-the-art postoperative care for patients who underwent HPB robotic surgery procedures 3) Counsel referring colleagues on HPB robotic surgery 4) Act in a multidisciplinary environment 5) Recognize and acquire emerging knowledge regarding HPB robotic surgery 6) Conceive, realize, present and publish research projects regarding HPB robotic surgery 7) Develop and support institutional programs related to HPB robotic surgery professional and societal policies
Structure of the curriculum	There are 8 core and 6 elective modules that each last 4 weeks (1 month). A fellow is obligated to follow the 8 core and, depending on the chosen pathway, another 4 elective modules. The available modules are: 1) Introduction to HPB robotic surgery / dVS phase 1. Technology of robotic surgery (online modules and dV training centre) / dVS phase 2. Robotic skills simulator / dVS phase 3II (core) 2) Dry laboratory skills simulator / dVS phase 3I&II (core) 3) Biliary 1, bedside and console / dVS phase 3I (core) 4) Biliary 2, console / dVS phase 3II (core) 5) Pancreas 1, bedside and console / dVS phase 3I (core) 6) Pancreas 2, console / dVS phase 3II (core) 7) Liver 1, bedside and console / dVS phase 3I (core) 8) Liver 2, console / dVS phase 3II (core) 9) Biliary 3, console / dVS phase 3II (elective, mandatory for the pure clinical pathway) 10) Pancreas 3, console / dVS phase 3II (elective, mandatory for the pure clinical pathway) 11) Liver 3, console / dVS phase 3II (elective, mandatory for the pure clinical pathway) 12) HPB robotic surgery clinical research / dVS phase IV (elective, mandatory for the clinical and research pathway) 13) HPB robotic surgery educational research / dVS phase IV (elective, mandatory for the clinical and research pathway) 14) HPB robotic surgery authorship / dVS phase IV (elective, mandatory for the clinical and research pathway)
Informative comments	Modules 1 and 2 include online and skill simulators training, and they are delivered mainly in the Department of Surgery Research Laboratory facilities. Modules 3–11 combine teaching with clinical work. They are delivered in the hospital and in the medical offices; depending on caseload, bedside modules (3, 5 and 7) and console modules (4, 6, 8, 9 and 10) may run in parallel. Modules 12–14 involve database analysis and utilization of skills simulators. They are delivered mainly in the Department of Surgery Research Laboratory facilities. Teachers, under the direct supervision of the program director (Dr. J. Martinie, MD, FACS), include all 4 HPB surgeons of the department, 2 HPB surgery fellows, medical researchers (2 PhD holders in experimental surgery) and various other medical faculty members (e.g., 3 information technology experts, 1 educationist, 1 lead medical writer).

AHPBA = Americas Hepato-Pancreato-Biliary Association; FACS = Fellow of the American College of Surgeons; HPB = hepato-pancreato-biliary.

into 8 core modules that are required for both pathways. The modules are based on the adult learning theory that emphasizes problem-based learning and active trainee participation.[8] Over the last several decades, medical education has shifted from teaching to learning owing to this theory; however, it is not only learning theories that influence a curriculum design, especially on a postgraduate level.[9] The trainee should also be able to identify and solve clinical problems in the real world with minimal to no supervision. Consequently, the medical curriculum at a postgraduate level should be problem-based and integrate knowledge, skills, and attitudes. In a word, it should be made for practice.[10] Thus, each of these proposed modules follow the principles of adult learning theory and are problem-based.

The curriculum begins with 4 core modules that follow a spiral model (Table 2).[3] Module 1 involves an introduction to robotics, discussing technology and equipment to allow for efficient use and appropriate troubleshooting. A robotic skill simulator is used to familiarize the trainees, and Module 2 follows with dry laboratory simulation to practise set-up basics to suturing anastomoses. The simulations are recorded to assess learning curves and areas for improvement. The next 3 modules focus on completion of simple index procedures, such as cholecystectomies, or core parts of larger complex cases while simultaneously advancing work in the dry laboratory (Figure 1). As competence increases, more complex procedures, such as pancreaticoduodenectomies and major hepatectomies, are taught in the subsequent core modules. After completion of the core

Table 2 (part 1 of 2). The HPB robotic surgery fellowship curriculum matrix aligning intended learning outcomes, teaching and learning activities and assessments

Module	Intended learning outcomes	Teaching and learning activities	Indicative content	Assessment
Introduction / technology / robotic skills simulator	1. Introduction to robotic HPB surgery 2. Learning the technology of the robotic platform 3. Improving robotic skills by simulation	1a. Lecture 1b. Video 2a. Online modules 2b. Hands-on course 3. Robotic skills simulator	1a. Trocar placement in robotic HPB surgery 1b. Video of a robotic PPPD 2a. Energy devices in robotic surgery 2b. Spatial considerations in robotic surgery 3. Mastering the 10 simulated robotic skills	1a. MCQ 1b. EMQ 2a. On line dV certificate 2b. dv Training centre certificate 3. MIMIC ratings
Dry skills laboratory	1. Perform docking 2. Perform simple tasks (modified simulation skills) 3. Perform customized tasks	1. Demonstration 2. Perform in dry laboratory 3. Perform in dry laboratory	1. Xi platform docking differences 2. Modified simulation skills 3. Dry laboratory construction of robotic PJ	1. Tutor / self assess 2. Video analysis 3. CUSUM learning curve
Biliary 1	1. Follow up of patients after robotic biliary surgery 2. Perform simple robotic biliary operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR 2b. Perform in OR 3c. Simulation laboratory	1a. Follow-up robotic CCY 1b. Planning of a proposed robotic CCY 2a. Bedside in a robotic CCY 2b. Console in a robotic CCY 3c. Dry laboratory robotic HJ	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis 3c. CUSUM learning curve
Biliary 2	1. Follow-up of patients after complicated robotic biliary surgery 2. Perform complex robotic biliary operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR, bedside 2b. Perform in OR, console	1a. Follow-up complicated biliary patients 1b. Planning of a redo biliary procedure 2a. Console in a robotic HJ, < 50% 2b. Console in a robotic HJ, > 50%	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis
Pancreas 1	1. Follow-up of patients after robotic pancreas surgery 2. Perform simple robotic pancreas operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR 2b. Perform in OR 2c. Simulation laboratory	1a. Follow-up robotic débridement patients 1b. Planning of a robotic débridement 2a. Bedside in a robotic débridement 2b. Console in a robotic débridement 2c. Dry laboratory construction of robotic PJ	1a. Mock patients / orals 1b. EMQ 1a. Tutor / self assess 2b. Video analysis 3c. CUSUM learning curve
Pancreas 2	1. Follow-up of patients after complicated robotic pancreas surgery 2. Perform complex robotic pancreas operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR, bedside 2b. Perform in OR, console	1a. Follow-up complicated PPPD patients 1b. Planning of a redo robotic débridement 2a. Console in a robotic PPPD, < 50% 2b. Console in a robotic PPPD, > 50%	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis
Liver 1	1. Follow-up of patients after robotic liver surgery 2. Perform simple robotic hepatic operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR 2b. Perform in OR 2c. Simulation laboratory	1a. Follow-up robotic LL rsxn patients 1b. Planning of a proposed robotic rsxn 2a. Bedside in a robotic LL rsxn 2b. Console in a robotic LL rsxn 2c. Dry laboratory robotic rsxn of an actual 3D-printed liver	1a. Mock patients / orals 1b. EMQ 2a. Tutor / Self assess 2b. Video analysis 2c. CUSUM learning curve
Liver 2	1. Follow-up of patients after complicated robotic liver surgery 2. Perform complex robotic hepatic operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR, bedside 2b. Perform in OR, console	1a. Follow-up complicated rsxn patients 1b. Planning of a redo rsxn 2a. Console in a robotic R rsxn, < 50% 2b. Console in a robotic R rsxn, > 50%	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis
Biliary 3	1. Follow-up of patients after complicated robotic biliary surgery 2. Perform complex robotic biliary operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR, bedside 2b. Perform in OR, console	1a. Follow-up complicated biliary patients 1b. Planning of a redo biliary procedure 2a. Console in a robotic HJ, < 50% 2b. Console in a robotic HJ, > 50%	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis
Pancreas 3	1. Follow-up of patients after complicated robotic pancreas surgery 2. Perform complex robotic pancreas operations	1a. Shadow office hours 1b. PBL 2a. Assist in OR, bedside 2b. Perform in OR, console	1a. Follow-up complicated PPPD patients 1b. Planning of a redo robotic débridement 2a. Console in a robotic PPPD, < 50% 2b. Console in a robotic PPPD, > 50%	1a. Mock patients / orals 1b. EMQ 2a. Tutor / self assess 2b. Video analysis

Table 2 (part 2 of 2). The HPB robotic surgery fellowship curriculum matrix aligning intended learning outcomes, teaching and learning activities and assessments

Module	Intended learning outcomes	Teaching and learning activities	Indicative content	Assessment
HPB robotic surgery clinical research	1. Describe current status of robotic HPB surgery clinical research 2. Explain how and why to choose a subject for robotic HPB surgery clinical research 3. Explain clinical research ethics 4. Describe methods of clinical research results dissemination 5. Design and conduct a clinical research project	1. Lecture 2. Tutorial podcast 3a. PBL 3b. Reflective journal 4. Lecture 5. Write a retrospective / prospective cohort analysis	1. Designing ergonomic triangles for trocar placement in robotic HPB surgery 2. How to address a clinical question with an evidence-based answer in the robotic HPB surgery era 3a. Data manipulation in robotic HPB surgery 3b. Inner thoughts of a clinical researcher 4. What to present in a scientific poster in the robotic HPB era 5. Oncologic outcomes after robotic PPPD	1. MCQ 2. Portfolio of 2 pojects 3a. EMQ 3b. Self / tutor assess 4. Prepare 4 abstracts 5. Clinical research projects × 2
HPB robotic surgery educational research	1. Describe current status of robotic HPB surgery educational research 2. Explain how to choose a subject for educational research in robotic HPB surgery 3. Explain educational research in robotic HPB surgery goals 4. Design and conduct an educational research project in HPB surgery	1. Lecture 2. Tutorial podcast 3a. PBL 3b. Reflective journal 4. Conduct experiment	1. Simulation training in robotic HPB surgery 2. Performing educational research that matters; improving residents' learning in robotic HPB surgery 3a. 3-D printing in robotic HPB surgery 3b. Inner thoughts of a trainee in robotic HPB surgery 4. Video vs CUSUM analysis in construction of a robotic PJ	1. MCQ 2. Portfolio of 1 project 3a. EMQ 3b. Self / tutor assess 5. Basic research project ×1
HPB robotic surgery authorship	1. Explain how to structure a scientific communication for robotic HPB surgery 2. Explain what to present on a scientific communication for robotic HPB surgery 3. Explain the ethics of scientific authorship in the era of robotic HPB surgery 4. Participate in a greater authorship project	1. Tutorial podcast 2. Tutorial podcast 3. Lecture 4. Write a chapter	1. Types of medical manuscript relevant to robotic HPB 2. Video editing of robotic HPB surgical procedures 3. The plague of selective reporting in robotic HPB surgery 4. Technical pearls for a robotic PPPD	1. Mock project 2. Prepare 2 videos 3. MCQ 4. Participate in the writing of the CMC Atlas of MI HPB surgery × 2 chapters

CCY = cholecystectomy; CUSUM = cumulative summary; EMQ = extended matching questions; HJ = hepaticojejunostomy; HPB = hepato-pancreato-biliary; LL = left lateral; MCQ = multiple choice questions; MIMIC = robotic simulator; OR = operating room; PBL = problem-based learning; PJ = pancreaticojejunostomy; PPPD = pylorus preserving pancreatoduodectomy.

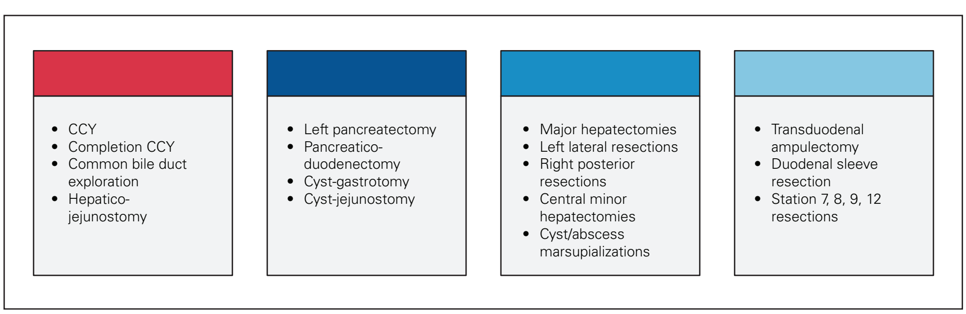

Fig. 1. Index robotic hepato-pancreato-biliary (HPB) surgical procedures performed at Carolinas Medical Center. CCY = cholecystectomy; LN = lymph node.

modules, an additional 4 elective modules are required. Vertical integration (between basic and clinical science) is achieved within each module and, depending on case-load, bedside modules (3, 5 and 7) and console modules (4, 6, 8, 9 and 10) may run in parallel.[11]

This curriculum focuses primarily on incorporation and importance of the cornerstone of intended learning outcomes (ILO), which is competence in performing hepatic, pancreatic and biliary operations. However, other important objectives, such as problem solving, researching, socialization and professionalism, are also incorporated and are considered equally important. These inform fellows of what they should achieve, guide teachers to what they should teach, and clarify assessment processes. All modules are structured to align each ILO with an appropriate teaching/learning activity and a meaningful assessment process.

As our intention is to produce highly specialized HPB surgeons who practise in a tertiary level hospital, teaching and learning activities include substantial operative

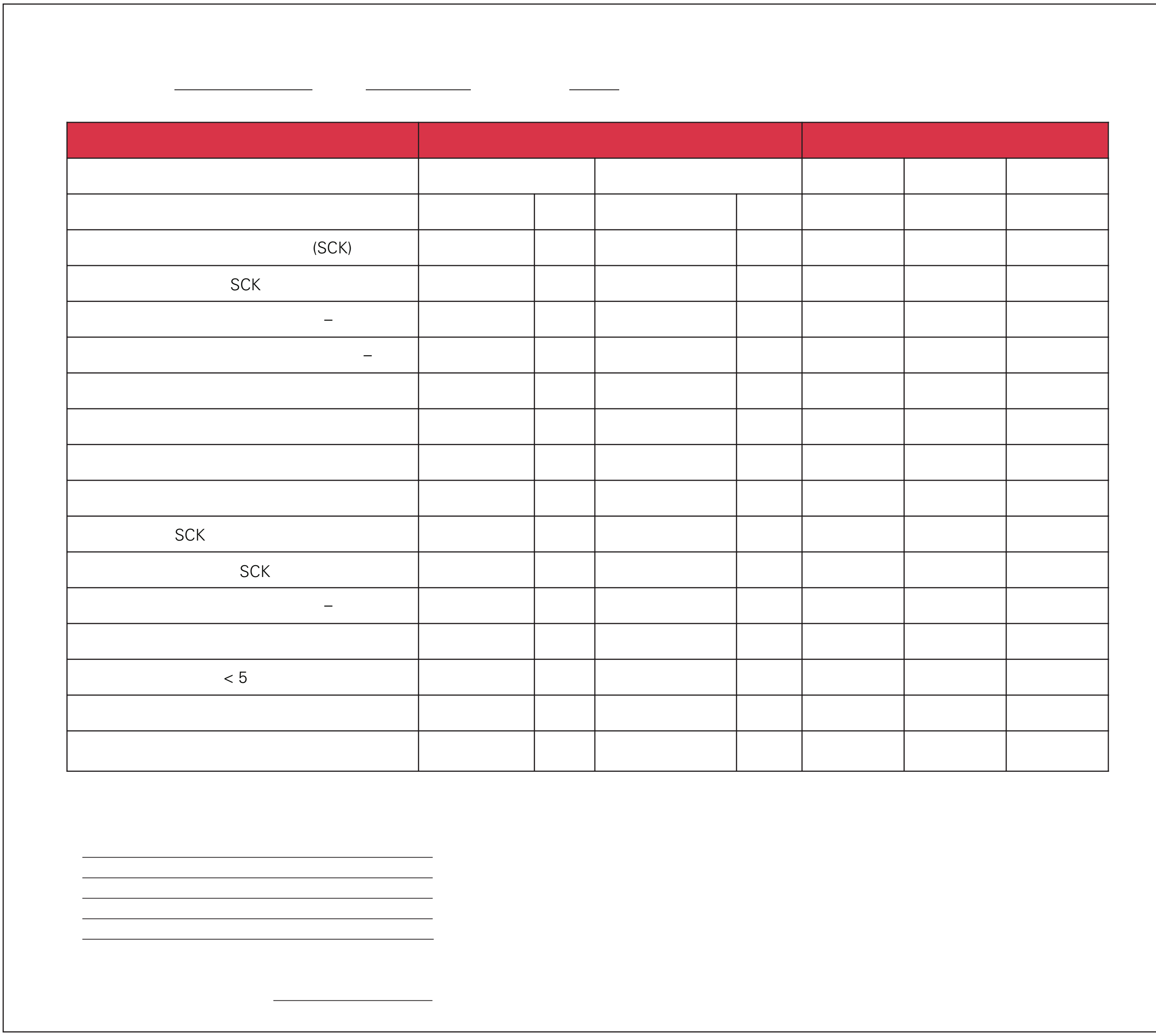

Fig. 2. Template for construction of a cumulative summary (CUSUM) learning curve. ERCP = endoscopic retrograde cholangiopancreatography; N/A = not applicable; PD = pancreatic duct.

exposure and in-house and outpatient treatment formulations. Each module, along with the operative objectives, focuses on appropriately planning and presenting a procedure. As a variety of teaching methods are needed for effective learning, every attempt was made to include more than 1 teaching/learning activity for each desired ILO. This is especially true for the core modules, where 67% of the ILOs (12 of 18) are aligned to more than 1 activity; in the elective modules, 27% of the ILOs (12 of 44) are aligned to more than 1 activity.

Evaluation is incorporated into the curriculum from the beginning (Figure 2). Many assessment tools are used to encompass data, analysis, judgments and interventions.[12] The evaluation plan utilizes criteria provided by the major HPB surgery governing bodies. The focus is shifted mainly to the first (learner's satisfaction), second (knowledge acquisition) and third (knowledge implementation) levels of evaluation. This promotes habits of improvement by engaging fellows with challenging clinical cases and via quality-improvement and patient-safety initiatives. It supports formation of professional identity by offering feedback, reflective opportunities and multi-aspect assessments.[13]

In concert with the competence-based education idea, the cornerstone ILOs aim to produce highly specialized surgeons who are able to perform simple and complex HPB operations.[14] To this effect, all core modules contain an ILO described by the phrase "perform an operation." The HPB surgery governing bodies define the key steps of all relevant operative procedures and suggest the minimum number of each procedure that should be performed to obtain the competence required to become an independent performer. However, these standards exist only for open classic laparoscopic HPB procedures. The learning curves for performing index robotic HPB surgical procedures are largely unknown and could vary substantially from trainee to trainee. For that reason, we incorporated cumulative summation (CUSUM) to plot the learning curve of each procedure for each individual trainee (Figure 2).[15] Adopting ILOs assessed by CUSUM analysis might require less time to achieve competence.[16] In addition, this type of individualized analysis allows identification of specific deficiencies in technical performance of each trainee, leading to suitable interventions for improvement. The curriculum employs both vertical and horizontal integration of disciplines to link theory to practice and to provide a "real" learning environment. The combination of core with various elective modules provides a comprehensive approach to building an HPB robotic surgery personality — an endeavour that requires interprofessional collaboration.

The emergence of robotic surgery into general and specialized surgical practices, including HPB surgery, continues to expand and holds considerable promise for future development. However, residencies and HPB fellowships provide an array of exposure to robotic surgery, resulting in inconsistent technique and ability among HPB surgeons. Often, the only structured training received is through the fundamentals of robotic surgery, designed to deliver only basic knowledge and skill. Thus, the training and exposure required to perform complex procedures is often lacking and, as such, it is important that robotic fellowships be created to allow for an appropriate transition of autonomy and acquisition of a safe and effective skill set. Our curriculum was developed and implemented for this exact purpose. We encourage any individuals who seek to widely incorporate robotics into their practice to seek out or create similar curricula that can provide the appropriate problem-based learning and complex skill acquisition.

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