Developing the Pediatric Gastrointestinal Endoscopy Unit: A Clinical Report by the Endoscopy and Procedures Committee

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ABSTRACT

There is significant variability in the design and management of pediatric endoscopy units. Although there is information on adult endoscopy units, little guidance is available to the pediatric endoscopy practitioner. The purpose of this clinical report, prepared by the NASPGHAN Endoscopy and Procedures Committee, is to review the important considerations for setting up an endoscopy unit for children. A systematic review of the literature was undertaken in the preparation of this report regarding the design, management, needed equipment, motility setup, billing and coding, and pediatric specific topics.

Key Words: endoscopy unit, endoscopy, pediatrics

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Endoscopy plays a critical role in the diagnosis and treatment of digestive disorders in childhood. Pediatric endoscopy has grown exponentially since its early beginnings as fiber endoscopy in the early 1970s (1). The location where these procedures are performed has shifted over time. Many endoscopy programs started in procedure or treatment rooms, whereas some of the nascent endoscopy units began in the operating room (OR). Gradually more institutions and facilities have begun using more specialized ambulatory endoscopy units.

The purpose of this NASPGHAN Clinical Report prepared by the NASPGHAN Endoscopy and Procedures Committee is to review the considerations in developing a pediatric gastrointestinal (GI) endoscopy unit. A systematic literature search using PubMed, MEDLINE, and Google Scholar was performed to identify abstracts and articles related to GI endoscopy and pediatrics. This report is meant to provide practical guidance by summarizing available expert opinions on the topic of setting up a pediatric endoscopy unit. Hospital administrators may find this of value when considering the resources needed for an endoscopy unit. None of the authors have a conflict of interest with manufacturers listed in this report. This document should be viewed as an overview rather than mandated requirements. Consideration of the practice type and location must be taken into account when analyzing the best approach for the topics to follow. Although the specifications of this report may be most relevant to North America, we hope the topics and discussion will be useful to centers worldwide. The recently published overview on setting up a pediatric endoscopy unit serves as a complement to this clinical report (2).

UNIT DESIGN

The proper design of the pediatric endoscopy unit can affect the overall experience of the patient and family. Recent emphasis has been placed on creating a family and patient-centered encounter promoting the pediatric patients' unique needs. Adult centers are often built with an emphasis to support large patient volume and to provide efficiency of time for both the patient and the endoscopist. Pediatric-specific facilities, in contrast, are focused on the patient experience with a goal to reduce anxiety and provide age-appropriate analgesia. It is important to keep this point in mind if adapting an existing endoscopy suite to be more pediatric friendly. Cartoons can be painted on the walls, medical equipment can be hidden, and child friendly accessories are examples of strategies employed to modify a unit for pediatric patients.

The growth of GI endoscopy as a specialized activity within healthcare has increased the need for specialization in both facility design and management skills. Historically, endoscopic facilities

grew within hospital environments, often using ORs and the existing skills of generic hospital personnel. The increasing demand for greater volume and complexity of services commonly strained this original arrangement. This led to the design of purpose-specific facilities and greater specialization by staff and administrators.

Unit Location

Many different models are currently in use to provide pediatric endoscopy ranging from an OR, shared adult/pediatric endoscopy suite, stand alone surgical center, dedicated pediatric endoscopy suite, or same day surgery center which shares ORs with other subspecialists. Each model has its own advantages and disadvantages. Use of the OR is often employed in small centers where the volume of patients is too small to support a specialized unit. This type of set up may be staffed by generic personnel and often results in decreased efficiency as elective procedures are often put on hold to allow for emergencies. Shared pediatric and adult endoscopy units and freestanding surgery centers are also frequently employed. A consideration of these set-ups is the potential for lack of pediatric-specific design and medical personnel specifically trained in the care of children and adolescents, although the advantages include proximity to adult expertise and equipment. A pediatric-specific model in which dedicated pediatric gastroenterology staff is present may allow for efficiency, complexity, and development of competencies.

Design of the Unit

This section is an adjunct to architectural planning and is a supplement to healthcare and building coding guidelines such as those laid out by the State Department of Health Services, State Fire Marshal, Joint Commission for Ambulatory Health Organizations, Medicaid and Medicare services, and so on. Thorough discussion should take place with the hospital system facility management or a state licensed architect familiar with healthcare facilities. The coding of these facilities will vary from state to state. There is also variability within North America, that is, Canada.

Space Planning

Anticipated procedure volumes provide useful space estimates based on planned procedure room utilization rates and ratios of procedure rooms to waiting spaces and recovery beds (3). Space projections should include the likelihood for growth in volume and potential of expansion of provided services over time. Considerations of space are among the most difficult and carry the greatest implications for overall construction costs (3). Consideration should also be given to patient flow (eg, check-in to procedure room and back to recovery) as well as proximity to the OR or intensive care units. If the institution will be performing GI motility procedures, planning for the Motility Laboratory in close proximity to the endoscopy areas should also be undertaken.

Procedure Room

The procedure room needs to be large enough to allow for the staff's safety when moving around the patient, allow for easy spinning of the stretcher and if the only procedure room in the unit be able to accommodate endoscopic retrograde cholangiopancreatography (ERCP) and fluoroscopy. In general, a procedure room should be at least 400 sq ft with more space often needed for advanced cases.

Two separate entrance/exit doors should provide access to the procedure room: 1 to allow for the entry of the patient and clean supplies, and the other for the removal of used equipment and specimens. Ideally, the reprocessing area is most efficient when it can be located directly adjacent to and shared with the other procedure rooms.

Care should be taken to allow for efficient storage and access of equipment and supplies. One side of the room should be dedicated to nursing. Nurses should have accessories, supplies, and medications available in cabinets directly behind them. On the other side of the room, the endoscopist should have a hand washing and charting area located directly behind for easy access. Anesthesia and their associated medication and supplies should be located at the head of the bed (4).

Procedure rooms should be equipped to provide CO_2, oxygen, suction, and adequate electrical socket outlets for ancillary equipment. Ceiling-mounted booms have a sleek and compact design to keep lines, cords and equipment off the floor and may be helpful depending on the room.

Although the most common facility used by adult populations is the freestanding ambulatory endoscopy center, the pediatric unit will likely have less demand for endoscopy than an adult population. Therefore, the pediatric unit may serve a dual purpose of inpatient and outpatient procedures, as opposed to a freestanding outpatient center. It should have easy access for outpatient populations, and be accessible to inpatients as well. Two recovery/preparation rooms per procedure room can be helpful.

When designing the unit, thought should be made to the sharing of facilities and resources with other departments. To prevent future problems, the architect and licensing agencies should be consulted regarding all possible uses of the unit, as regulations may vary based on the intended use. For example, if the Pulmonary service at the hospital will be sharing the space to perform bronchoscopy, the state guidelines for airflow must be reviewed and accommodated to be certain negative airflow is provided (refer to jurisdictional guidelines). The Anesthesia service will also need proper scavenger systems, wall oxygen, and suction to support all possible procedures. Attention to these areas may prevent the possibility of retrofitting after the unit is already built.

Reception and Waiting Rooms

Easing anxiety on the day of the procedure begins with a well-designed entry. The waiting area should be child friendly with adequate seating for the patient, parents, and other accompanying children. Making the waiting room as home-like as possible has been shown to reduce anxiety for both the parents and the patient (5).

Bathrooms should be easily accessible, and special considerations should be in place to accommodate obese patients or handicapped patients in a wheelchair.

Preparation and Recovery Rooms

The comfort level and the efficiency of the unit may be improved with dual-use preparation and recovery rooms. The preparation and recovery rooms should be in direct view of the nursing station. Using the same area for both recovery and preparation allows for efficient post-procedure counseling between the gastroenterologist and the family, mobility of space and staff, and maximum flexibility. In another model, the flow would have different areas for recovery and pre-op. Advantages of separate areas include simplicity and specificity of design, patient confidentiality, and space conservation of the preparation area. The model may also be dependent on whether anesthesia or conscious sedation is used, as recovery times are different.

Reprocessing Area

Between 1966 and 1992, literature review found 281 instances of pathogen transmission were attributed to GI endoscopy (6,7). Contaminated endoscopes have been linked to many outbreaks of device-related nosocomial infections. The true incidence of infections is, however, unknown because of inadequate surveillance or no surveillance at all (8). Most recently, an outbreak of multidrug resistant pathogens from endoscopes used in ERCP has led to new Food and Drug Administration (FDA) safety communications and more stringent reprocessing guidelines (6).

The FDA recently indicated that the complex design of the duodenoscope, specifically the elevator mechanism, is believed to present challenges for high-level disinfection (9). The Centers for Disease Control has also issued an interim duodenoscope surveillance protocol, which urges centers to consider regular culture monitoring to assess the adequacy of duodenoscope reprocessing (10).

In addition to adherence to general endoscope reprocessing guidelines and practices established by the infection control community and endoscopy professionals, it is important to follow specific reprocessing instructions in the manufacturer's labeling for each device. At minimum, endoscopes should be reprocessed according to the FDA labeling and device-specific manufacturers' instructions. There are many unresolved and unstudied issues related to scope reprocessing. Because of this uncertainty, regulation regarding the reprocessing of endoscopy equipment is in flux and is beyond the scope of this document.

An updated document by ASGE in 2011 further discusses reprocessing issues for various endoscope attachments and mentions newly recognized issues for which there are incomplete data with which to guide practice (11).

Other Areas to Consider

Staff changing rooms are not usually required by state licensing and national authorities. The guidelines for this are, however, in transition, and having a small sex-specific staff changing room can ensure future compliance if necessary.

When designing a new unit, it would be prudent to create at least 1 procedure room large enough (450 sq ft) to allow for expansion for ERCP and fluoroscopy. It is recommended that fluoroscopy rooms be leaded, although the requirements for this vary within states and provinces (12).

Several potential trends can now be anticipated that may influence the size, use, and staffing of endoscopy units. For example, the advent of capsule endoscopy may prompt its placement in an endoscopy suite given the need for a location for computer equipment for uploading and image viewing (3).

A work area for physicians is an important consideration so endoscopists can complete procedure notes, enter patient orders, and coordinate care by phone.

Including a room for consultation with patients and family to allow for confidential conversation should also be considered when designing an endoscopy unit.

UNIT MANAGEMENT

Staffing

Ongoing advances in endoscopic capabilities have led to a significant increase in available diagnostic and therapeutic procedures. Providing these capabilities requires well-trained specialized endoscopy staff. The Society of Gastroenterology Nurses and Associates (SGNA) has published guidelines suggesting the minimum number of qualified personnel during endoscopic procedures (Table 1) (13). Although these guidelines are helpful, there is a lack of universally acceptable qualifications for training endoscopy staff. Running a cost effective and safe endoscopic practice is a balance between appropriate staffing and the expense of maintaining that staff (13). A qualified endoscopy assistant may be a registered nurse (RN), a licensed practical nurse (also known as a Registered Practical Nurse in Canada) or a nursing assistive personnel.

Before making a decision about the number of staff needed it is important to consult the Nurse Practice Act of each state to

TABLE 1. Suggestions for staffing an endoscopy unit

Work area	Minimum staff requirements	Duties
Preprocedure area	One RN per two patients	Patient assessment before sedation and IV start
Procedure room	One RN	Monitor patient during procedure. When anesthesia provider is providing sedation, RN will assist healthcare team
	Extra member of endoscopy team should be present for Unstable patients Pediatric patients Complex procedures (ERCP, PEG, emergency cases)	
Postprocedure area	One RN per two patients	Patient assessment during recovery from analgesia and sedation
Reprocessing room	One appropriately trained staff	Equipment care and disinfection
Medical staff office/physician affairs	Medical administrator	Credentialing, privileging, maintenance/oversight of professional standards
Human resources	Nursing administrator	Nursing care plans, hiring, credentialing, privileging, training, staffing, and maintenance of competencies for nurses and other allied health staff (3)
Management	Medical director	Manage doctors, nurses, plan unit expansion and utilization, make financial decisions, assess equipment needs and purchasing, and oversee quality improvement activities. Should also maintain relationships with other departments such as radiology, surgery, and pathology

ERCP = endoscopic retrograde cholangiopancreatography; IV = intravenous; PEG = percutaneous endoscopic gastrostomy; RN = registered nurse.

determine the scope of practice of each practitioner. This information can be found at *https://www.ncsbn.org*. A GI RN has the skill sets to be in charge of nursing assessment, diagnosis, outcome planning, and evaluation of the education and competency level of assistive personnel. The GI RN is able to assess the past medical history, possible medication, fall and bleeding risks, and review of systems as they pertain to the procedure. In most states, administration of intravenous medications and conscious sedation monitoring require an RN. This is not as much of an issue in pediatric endoscopy due to the trend to use specialized anesthesia staff (MD, certified nurse anesthetist) for sedation. Because of the shortage and expense of hiring qualified endoscopy nurses some units also employ nursing assistive personnel (GI assistants, GI technicians, GI technical specialist, advanced GI technical specialist). Assistive personnel should demonstrate competence in the duties they are assigned to. They are encouraged to complete the SGNA GI Associate's Program but this is not a requirement. In cases in which the pediatric endoscopy unit functions as a part of an adult endoscopy suite, the nursing staff need to have the specific skill set required to work with pediatric age groups. Ability to communicate with parents, secure intravenous access in small children, and knowledge of applicable pediatric endoscopic and resuscitation equipment are important.

Maintenance of certification and licensing of endoscopy nurses are state specific (*http://ce.nurse.com/RStateReqmnt.aspx*). SGNA-certified GI nurses need continuing education units to maintain certifications. This can be obtained through conferences, in-service activities, or accredited online courses. Even if the state does not require ongoing educational activities it would be prudent for the endoscopy suite to have annual assessments and training set up for all employees.

Endoscopy managers can be nurses or human resources personnel and are instrumental in establishing ongoing in-service training for all endoscopy staff as well as maintaining up to date procedure binders and succession plans. Ensuring job satisfaction can create an effective team and minimize turnover.

Determining Staffing Requirements

Determining the number of staff needed to run the endoscopy unit is dependent on many factors. Availability of equipment, time, type of procedures, complexity of patients, and possibly presence of learners all play a role in determining the unit's capacity and thus staffing requirements. Many centers do not have enough volume of pediatric endoscopy cases to function independently. In those cases, working within the adult endoscopy suite may be cost effective.

Several equations have been developed to estimate the minimum number of personnel needed to run a unit (14). All of these equations originate in the adult literature and need to be modified according to each unit's efficiencies and specifications. It may be best to calculate staffing needs by approximating the capacity of each endoscopy room that needs to be staffed. For example, an academic teaching center can perform approximately 1000 procedures per year per endoscopy room. A busy adult private practice can complete up to 3000 endoscopies in each room. Employing 1.5 licensed practical nurses per room if no designated anesthesia staff is available has been suggested (3). Staffing considerations should also take into account the procedures performed outside the endoscopy unit, that is, mobile cart transported to intensive care unit or main OR.

Calculating Unit Capacity

OR times should be used as efficiently as possible; however, no unit operates at 100% efficiency. It is helpful to develop a weighted scale per procedure such that an esophagogastroduodenoscopy (EGD) may be set a value unit of 1 and may be allocated anywhere from 15 to 60 minutes depending on the hospital and turnover time. All other procedures can be given value units based on how many ''EGDs'' fit in that time slot (15).

Tomer et al (16) described their experience at an academic children's hospital. They allocate 60 minutes for each EGD and each colonoscopy, and 90 minutes for combined EGD and colonoscopy cases. This time includes anesthesia induction, procedure time, anesthesia recovery, and turnover time. At the Children's Hospital Wisconsin 20 minutes are allocated for an EGD, 45 minutes for a colonoscopy alone, and 65 minutes for EGD and colonoscopy (personal experience). Another 15 minutes is given for set up and 10 minutes for clean up. If advanced procedures are expected such as dilation, injection, or polypectomy, an extra 15 to 20 minutes are added per case depending on the preference of the endoscopist. Many outpatient procedures are done in morning blocks so as to limit fasting time in young children, and this is also a consideration when projecting volumes.

In a setting where learners are performing the procedure, a possibility of increased procedural time should be considered depending on the center. Each center would need to calculate their own weighted scale per procedure depending on the number of complex procedures performed such as ERCP or motility procedures. Anesthesiologist or nurse anesthetist administered sedation may require another 10 to 15 minutes added to each case or more if residents and medical students are participating in sedation.

Optimizing Efficiency

Room efficiency is determined by intrinsic factors such as patient delays, scheduling conflicts, and equipment maintenance. Assuming a room can be productive 75% to 85% of the time would be a reasonable goal (17). Because each unit has a unique set of variables regarding personnel, equipment, flow, and culture, it is difficult to generalize one unit's attempt to improve efficiency. Each unit should develop an ongoing quality improvement program that is able to identify problem areas and bottlenecks and involve all staff in the process.

When conducting a time study, it helps to break up the day into patient controlled time (arrival), anesthesia controlled time, surgeon controlled time, and turnover time (time between end of case and new patient in the room) (18). Acceptable turnover time has been described anywhere between 10 and 30 minutes and depends on recovery and choice of anesthetic. Each unit should set a realistic goal for each time frame and measure it periodically. Having baseline data analysis will allow for identification of process breakdown and ability to intervene. Even seemingly small interventions such as educational programs and monthly meetings about decreasing delays can have significant effect on OR efficiency especially when the issue is with availability of appropriate personnel (18).

Reminder patient notifications within 24 hours of the procedure can minimize late arrivals (16). Patient no-show at time of procedure may be an important barrier to improved efficiency. Preprocedure interventions have been shown to be effective in decreasing the no-show rate in pediatric endoscopy (19). On time starts and decreased turnover time can maximize room efficiency when OR time is the main concern (16). If room availability is not an issue, then allocating 2 rooms to each endoscopist may decrease wait time between procedures and increase efficiency.

It may be helpful to have physicians and groups work in block schedules and have all documentation including consent prepared in advance (14,16). In some units, the endoscopist will perform any procedure in his or her allocated block time even if the

patient is not directly under his or her care. This model can decrease time to procedure and may be offered to patients who are not set on their endoscopist performing the case. Block time should be re-evaluated periodically and optimized to each physician's needs.

For hospitals that have both inpatient and outpatient procedures in the endoscopy unit, there are additional challenges such as coordination of patient transport, unstable patients, and emergency cases. Northup evaluated the utility of triaging patients who need an inpatient endoscopy by blocking off early morning hours of each day for urgent cases. This system significantly improved timely discharge of inpatients, limited delays in scheduled cases, and decreased overtime pay (20).

Interventions targeted toward improving efficiency are summarized in Table 2 and based on establishing an ongoing assessment of the endoscopy unit. Quality improvement programs should be done at least annually and all personal should have an avenue to initiate and participate in quality improvement. Patient satisfaction surveys should be used as an indicator of quality of service. An effective patient satisfaction program should allow for patients and parents to give feedback about their experience wait time, bowel preparation, pre-op instructions, the day of the endoscopy, and postprocedure follow-up. A recent study on patient experience in pediatric endoscopy identified important aspects from the patient and family perspective (21).

Emergency and Weekend Coverage

Plans for staffing should be determined for weekend and after-hour emergencies. The availability of an on-call and weekend endoscopy nurse is associated with earlier upper endoscopy for evaluation of bleeding (17) and has been shown to be cost effective for patient discharge (24). Some units schedule a late shift that routinely covers after-hours and overnight emergencies. Another option is to schedule a nurse to cover emergencies at all times for 3 to 4 days at a time, several times per week. This relieves the endoscopist of the responsibility to transport the endoscopy cart, procedure set-up, cleaning, and reprocessing. On-call staff should be qualified to function independently in those areas. It is not always necessary to have a specialized RN available for patient monitoring if one can float from another department (emergency room, surgical suite, ICU, or a floor unit). The on-call designee should be able to arrive at the hospital in 30 to 45 minutes. More specialized staff may need to rotate call for emergency ERCPs, endoscopic ultrasound (EUS), and enteroscopies due to the specific technical considerations (3).

In institutions where after-hours endoscopy nurses are not available, the OR is used to perform urgent procedures. This means procedures are done with nurses who are likely not trained for endoscopic procedures. Thus, cost, efficiency, and volumes must be considered when designing the after-hours strategy for an endoscopy unit.

Documentation

A standard approach to documentation should have the following objectives:

1. The capacity to perform quality assurance reviews.
2. Clear evidence of following an accepted standard of care.
3. Establishing a rationale for any deviations from the standard of care and the consent of patients/families to do so.
4. Accessing pay for performance funds.
5. Medicolegal considerations.

There are 3 broad areas of documentation in a pediatric endoscopy unit: nursing documentation before and after procedure, the procedure itself, and sedation record if a separate provider administers sedation. The Joint Commission on Accreditation of Healthcare Organizations provides guidance on components of documentation (25). Table 3 provides a brief comparison of the different products available. A particular challenge to consider when comparing products is the capability of importing the procedural record into the hospital electronic health record.

Nursing Record

The nursing record must record a patient's arrival, vital signs at presentation, and identify any specific issues to address before beginning the procedure. During the procedure, documentation should include verification/placement of intravenous line, all personnel present in the endoscopy unit at the time of the procedure including observers and students, verification of allergies, and verification of ''time out'' before starting the procedure. After the procedure, the record must document vital signs as per the standard protocol for postsedation monitoring, and have criteria for determining appropriateness for discharge home.

TABLE 2. Interventions to improve efficiency

Target area for improvement	Intervention
Personnel not available at time of procedure, late first case starting time	Establish arrival time monitoring programs and conduct monthly meetings to discuss outcomes
	Block scheduling
	Documentation/consent ready in advance
	Consequences for late arrivals (loss of early morning case time) (18)
Late patient arrivals	24-Hour advance notification reminders
	Capacity to shift patients around (some overlap) (16)
High no-show rate	Reminder phone calls
	Social worker intervention to address barriers to attending appointment (19)
Prolonged turn over time	Two rooms per endoscopist
	Incentives to staff for efficient flow
	Recognition programs
	Ongoing evaluation of bottleneck (22)
Long wait list	System to release unused time 2–4 days in advance
	Expanding number of operational rooms (23)
Large number of add-on cases	Block early morning slots of inpatients

TABLE 3. Products available for gastrointestinal procedure documentation

	Web site	Image management	Video clip management	Remote internet access	Standardized reports	Interface with Meditech	Integration with EMR
Endoworks (Olympus)	*www.endoworks.com*	Y	N	Y	Y	Y	Y
EndoPROIQ	*www.pentaxmedical.com*	Y	Y	Y	Y	Y	Y
Provation MD	*www.provationmedical.com*	Y	Y	Y	Y	Y	Y
Endoprose	*www.summitimaging.net*	Y	Y	Y	Y	N	Y
Endosoft	*www.endosoft.com*	Y	Y	Y	Y	N	Y
Studio3	*www.stryker.com/mediamanagement/*	Y	Y	Y	N	N	N
gCare EMR	*www.gmed.com*	Y	N	Y	Y	N	Y
MD-Reports	*www.md-reports.com/endoscoy-report-writer.html*	Y	Y	N	Y	N	N
Mediscope	n/a	Y	Y	N	Y	N	N

EMR = electronic medical record.

Procedure Record

The American College of Gastroenterology determined elements to include in endoscopy reporting (26).

The Canadian Association of Gastroenterology does not provide specific recommendations for documentation, but rather counsels individuals to check with their provincial/state licensing body for documentation requirements (27). Cross-referencing the ACG documentation guidelines with one provincial licensing authority (28) yields the following list:

1. Date of procedure
2. Patient identification data
3. Endoscopist(s)
4. Assistant(s)
5. Documentation of relevant patient history and physical examination (if performed at the time of endoscopy)
6. Indication of informed consent
7. Type of endoscopic procedure
8. Statement of ''time-out'' (team pauses to have patient/caregiver state name, date of birth, drug allergies, and confirm what procedure is being carried out)
9. Site markings before performing a procedure may be required by the institution
10. Indication(s)
11. Type of endoscopic instrument
12. Medication (anesthesia, analgesia, sedation), or statement of separate sedation provider and record
13. Anatomic extent of examination
14. Limitation(s) of examination
15. Tissue or fluid samples obtained
16. Findings
17. Diagnostic impression
18. Results of therapeutic intervention (if any)
19. Complications (if any)
20. Disposition
21. Recommendations for subsequent care

Sedation Record

If another provider administers sedation, or general anesthesia is used, a separate record should be completed by that provider. Anesthesia records generally include the following:

1. Date of Procedure
2. Patient Identification data
3. Sedation provider
4. Fasting status
5. American Society of Anesthesiologists class
6. Indication for procedure and risk factor
7. Airway description
8. Medication used for inducing and maintaining sedation, and time of administration
9. Documentation of vital signs at specified time points
10. Complications (if any)
11. Handover to post-anesthetic care

EQUIPMENT

Endoscopes have advanced from a restricted eyepiece view with limited capability to inspection of the entire intestinal tract using high-definition video and a large range of interventions that have reduced the need for surgical intervention in a variety of conditions. Pediatric patients often have limitations in therapy due to size and approved measures.

Basics

Gastroscope

The choice of gastroscope is dependent on the size of a patient and is designed with a directly proportional auxiliary channel. A child weighing >20 kg will frequently accept a standard adult size gastroscope, whereas a patient weighing <5 kg may require an ultrathin or neonatal gastroscope ≤6 mm in outer diameter (OD). For the small child weighing 5 to 20 kg, a slimmed down gastroscope ≤9 mm is preferable and it is advantageous to have a smaller endoscope available in the event the preselected endoscope is not appropriate. Depending on the manufacturer, the channel size varies on the slim gastroscopes (Table 4) (29).

An ultrathin or slim adult gastroscope with an auxiliary/working channel 2.0 to 2.2 mm attenuates the suction capacity when compared to the 2.8 mm channel. This in combination with fewer devices that fit into the smaller channel limits the therapeutic options available in a smaller patient (30).

Colonoscope

A pediatric (11–12 mm OD) colonoscope or standard adult gastroscope may be used for a 5 to 20 kg child, whereas an ultrathin

TABLE 4. Diagnostic endoscopy

Size of child, kg	Esophagogastroduodenoscopy	Colonoscopy
<5	Ultrathin gastroscope ≤6 mm OD (2.0 mm channel)	Ultrathin gastroscope ≤6 mm OD Thin colonoscope
5–20	Slim adult gastroscope 7.8–9 mm OD (2.2–2.8 mm channel)	Adult gastroscope or pediatric colonoscope 11–12 mm OD (2.8–3.8 mm channel)
>20	Adult size gastroscope 9–10 mm OD (2.8 mm channel)	Pediatric colonoscope or adult colonoscope 12–14 mm OD (3.2–4.2 mm channel)

OD = outer diameter

gastroscope can be used for an infant <5 kg. A pediatric colonoscope or adult colonoscope (12–14 mm OD) is suitable for a child >20 kg and has working lengths 1680 to 1700 mm (Table 4). All colonoscopes have an auxiliary channel ≥2.8 mm, and any device needs a working length greater than that of the colonoscope. When the objective of the procedure is simply to observe or biopsy the distal 20 to 40 cm of colon/rectum as in a flexible sigmoidoscopy, an appropriate sized gastroscope may be used with the corresponding forceps as an alternative to a colonoscope or sigmoidoscope.

Tissue and Sample Acquisition

Biopsy forceps include design options such as disposable versus reusable forceps and cup with or without needle spike. Disposable forceps may be more reliable and cost effective, but operator preference is a consideration. Hot biopsy forceps may be useful for raised vascular lesions or gastric polyps to allow for hemostasis. Cytology brushes for obtaining fungal elements throughout the upper GI tract are available for all endoscope channel sizes. A polyp trap may also be used to obtain duodenal contents for culture or pancreatic stimulation test. Table 5 gives an overview of endoscopic accessories.

Light Source and Video Processor

The endoscope is connected to a light source and video processor that transmits an image to software for further management. The processor and light source may be separate units versus a combined unit depending on the manufacturer (Table 6). Xenon gas is used in the light source in newer units rather than halogen in older units. It should be noted that the endoscope, light source, and video processor are not interchangeable between manufacturers. The video processors have either standard (SD) analog or digital high definition (HD) video output with variable zoom features. Many of the new processors have narrow band imaging that is used in the detection of dysplastic lesions in adults, although pediatric use has not been defined. The cost of each unit is highly dependent on the digital interface and resolution of each processor.

Image Management

The images (single still image and/or video clip) captured from the endoscope are transmitted to a hard drive for management and storage. The image management software may be purchased separately or combined with the video processor depending on the manufacturer. Each image management program has unique capabilities and is at the discretion of the reader to consider image format, video format and editing, and procedure documentation.

Therapeutic Endoscopy

Treatment of nonvariceal bleeding by means of endoscopy includes injection, tamponade via clip placement, and cautery. Therapeutic measures that can be taken are dependent on the number and size of channels available in an endoscope. Hemostatic clips are designed for channels ≥2.8 mm and should be available for

TABLE 5. Endoscopic accessories available for 2.0 and 2.8 mm Channels (29,30)

Intervention	2.0-mm Channel*	2.8-mm Channel
Tissue acquisition		
	Cold biopsy forceps, ±needle spike	Cold biopsy forceps, ±needle spike
Retrieval devices		
	Alligator forceps	Alligator forceps
	Rat-Tooth forceps	Rat-Tooth forceps
		Rubber-tip forceps
	Minibasket, 3-, 4-wire basket	3-, 4-, 6-Wire baskets
	3-,4-Prong grasper	2-,3-,4-,5-Prong Grasper
	Pediatric Roth Net	Roth Net
	Polypectomy snare	Polypectomy snare
Hemostatic devices		
	Injection needle	Injection needle
	Bipolar probe	Multipolar/bipolar probe
	Argon plasma coagulation probe	Argon plasma coagulation probe
		Monopolar hot forceps/hemostatic grasper
		Hemostatic clips
		Variceal Band Ligator

*Must specify that smaller device is designed for 2.0-mm channel when purchasing.

TABLE 6. Light source, video processor, and image management

Manufacturer	Light source (gas in watts)	Video processor (signal output)	Image management
Olympus (separate)	CLV-190 (300w Xenon)	CV-190 HD (1080i) or SD (480i)	Endoworks
	CLV-180 (300w Xenon)	CV-180 HD or SD	Endoworks
Pentax (combined)	EPK-i5010HD (300w Xenon)	HD or SD	endoPRO iQ
	EPK-I (300w Xenon)	HD or SD	endoPRO iQ
	EPK-1000 (100w Xenon)	SD	endoPRO iQ
Fujinon (separate)	XL-4450 (300w Xenon)	VP-4440HD HD (1080i) or SD	EndoGI (Summit Imaging)
(Combined)		EPX-2500 HD (960p) or SD (480i)	EndoGI (Summit Imaging)

nonvariceal bleeding cases. The current hemostatic clips are not designed for a channel <2.8 mm and consequently are not an option for many of the slim or ultrathin gastroscopes. Injection needles, bipolar probes, heater probes, and argon plasma coagulation are all, however, offered for a smaller channel. In variceal bleeding, band ligators are made for an endoscope as small as OD 8.6 mm, although the barrel to which the bands are fixed may be too large to fit past the upper esophageal sphincter. Having the equipment arranged in a ''bleeding kit'' for emergencies can be a helpful strategy to decrease time spent looking for equipment.

Foreign Body Retrieval

Children have a penchant for swallowing foreign objects that can cause considerable damage to their intestinal tract. Safe and efficient removal of button batteries, magnets, and sharp objects is an important aspect of an endoscopist's practice. The recently published NASPGHAN Clinical Report on management of ingested foreign bodies is a valuable resource (31). For blunted objects, a variety of retrieval tools including graspers (rat-tooth, alligator) are available and should be selected based on the user's experience. A retrieval net is particularly useful for removal of coins and batteries and is also made for colonoscope polyp retrieval. An endoscopic overtube prevents overt injury from sharp objects and assists in removal of food impaction. Similar to bleeding, a ''foreign body kit'' can be used to organize a variety of tools for these cases and decrease time spent looking for equipment.

Visibility in Colonoscopy

It is not uncommon for a child to have difficulty completing a bowel preparation solution that creates a difficult examination for the endoscopist. An additional flushing pump and direct suction device can increase the visibility and completion of a colonoscopy, reducing incidence of an incomplete evaluation, and can also be used during therapeutic EGD for clearance and evacuation of food particles or blood.

Historically, room air has been used to insufflate the colon with relative ease but can cause prolonged distension and increase the risk for perforation if not monitored closely. Over the past 30 years there has been increasing use of carbon dioxide for colonic insufflation as surgeons have used for laparoscopic procedures. Carbon dioxide is 150 times more soluble than air and has been associated with increased patient comfort and increased parietal blood flow compared to air in an animal model from both a reduced colonic distension time and its vasodilatory effects on blood vessels. At this time there is no consensus on the use of carbon dioxide for colonic insufflation in adults other than it is a safe method in sedated and unsedated patients and should be used at the discretion of the provider and institution (32).

Endoscopy in the Obese Patient

The obese child presents additional consideration before and during an endoscopic procedure. Obese children are at increased risk for intraoperative oxygen desaturations and unexpected hospitalization after routine outpatient dental procedures and tonsillectomy (33). Assessing for obstructive sleep apnea in an obese patient before the procedure assists in predicting those at risk for perioperative airway and sedation complications. Specific beds and tables may also be needed.

With regard to colonoscopy in adults, having a body mass index ≥25 is an independent predictor of inadequate bowel preparation (34). Moving an obese patient into the left lateral position poses a difficult maneuver for the OR staff and may not be safe if the bed is not large enough. Having the patient in the prone position may provide a more feasible position for the endoscopist to reach the rectum with freedom to maneuver the colonoscope.

Wireless Capsule Endoscopy

In the United States, capsule endoscopy has become readily available. The overall system requires the image capturing capsule, a wireless recorder, and a computer with the designated software. The devices are 26 mm in length and 11 mm in diameter, a large pill to swallow for a child, and can be placed by endoscopy using a capsule cup attached to a catheter that allows for manual deployment. The systems advertise a run time of 8 hours at 2 frames per second and 6 LED lights. A handheld real-time viewer is also available for the systems.

If a patient is unable to swallow the capsule and undergoes general anesthesia for capsule placement, the device can be placed past the pylorus in the duodenal bulb. A real-time viewer can also assist in the placement of the capsule (35). After 8 hours, the recording device can be removed and returned. The images can then be uploaded to the appropriate computer and analyzed.

For patients in whom intestinal stenosis is suspected, either from stricturing disease or previous surgery, a patency capsule is recommended (36). The patency capsule can be swallowed and if not passed within 40 hours, will dissolve in a liquid environment. The capsule contains a small radiopaque center small enough to pass through an intestinal stricture.

Purchase Versus Lease

Endoscopic equipment can be purchased used or new or leased for a predetermined amount of time. Just the basic endoscopy

equipment including the endoscope, light source, video processor, and image management software will cost upwards of $100,000. For an academic center or a group practice with a large volume, purchasing endoscopy equipment is usually more cost effective than leasing with extended use beyond 3 to 4 years, as the cost is readily reaccrued (3). Equipment can be purchased as an initial startup package with a smaller portion replaced at intervals.

The cost of leasing equipment is usually structured based on the number of procedures performed (price-per-procedure basis) over a given period of time (2–5 years) the equipment will be used for. Leasing may be more cost effective for smaller volume endoscopy units or when equipment turnover is anticipated. Leasing may give an endoscopist access to newer equipment and technology at a fraction of the cost. A cost analysis should be performed to evaluate the reimbursement rate for each procedure versus the cost per procedure under the lease to assess feasibility. There may also be an option to purchase the equipment at the end of the lease, similar to leasing an automobile. Repair costs and service agreements should be factored into the decision making when considering options.

Endoscopy Equipment Needs

There are no pediatric data describing the optimal number of endoscopes and equipment needed to maximize endoscopy unit efficiency for children. When planning equipment for large and small adult endoscopy units, Petersen and Ott (3) suggest as a starting point ''one colonoscope and gastroscope for every 350 procedures per year; 1 light source and processor per endoscopic procedure room; and 1 scope reprocessor for each 1000 procedures per year''. Other specialty endoscopes, such as neonatal and therapeutic instruments (ERCP, EUS) may be needed to provide comprehensive endoscopy services.

GASTROINTESTINAL MOTILITY LABORATORY

The goals of motility testing are to allow the assessment of GI pathophysiology and to identify patterns of abnormal physiology. A well-equipped GI motility laboratory can provide the correct diagnosis of motility disorders, guide treatment, and provide prognostic information. Advances in technology have greatly improved the ability to measure intestinal motility and its functions in an ambulatory setting. A comprehensive GI motility laboratory is an ideal opportunity to conduct both clinical and basic science research, thus advancing the level of diagnostic sophistication in gastroenterology. Several items need to be considered in setting up a practical and efficient GI motility laboratory, including the room, equipment, procedures to be performed, billing and coding, and personnel to staff the laboratory.

Gastrointestinal Motility Room (37)

1. A room (minimum 14×16 ft) to accommodate the necessary equipment and a comfortable bed that can be raised or lowered easily. Often patients may be having endoscopic procedures with manometric procedures, making the GI endoscopy suite location practical.
2. Nearby restroom
3. A large sink for cleaning equipment
4. Cabinets for storage of supplies

Equipment and Procedures

Equipment for a GI motility laboratory depends on the procedures performed and types of patients seen in the center. The laboratory should have the expertise to perform certain minimum tests (37):

1. Esophageal manometry
2. Esophageal pH/impedance monitoring
3. Anorectal manometry

Specialized Procedures

1. Antroduodenal manometry
2. Colonic manometry
3. Smart pill

Different types and brands of equipment are used for procedures performed in the GI motility laboratory. Different equipment may perform slightly different tests that assess functions and provide information. The performance characteristics and extent of recording ability of these devices differ and need to be considered, depending on the need of the individual laboratory. There are options for tests to be performed with water-perfused catheters or with solid-state catheters, using conventional spacing of the recording channels or high-resolution systems. 3-D feature is also available. In addition, manometry can be combined with impedance to measure esophageal transit and subtler esophageal motor disorders. For esophageal pH monitoring, one can use a catheter pH probe with 1 to 3 pH recording sites, a catheter probe with pH and impedance measurements, or capsule pH monitoring (Bravo pH).

Equipment in the laboratory should be FDA approved with high fidelity. Maintenance of the equipment is important, and cleaning and sterilization between procedures, and regular bioengineering inspection and service, are essential. The laboratory should also demonstrate appropriate data acquisition and storage capabilities (archival storage and so forth).

Technical and Professional Staff

The director of a GI laboratory is most often a gastroenterologist interested in GI motility and functional bowel disorders (37). Training during gastroenterology fellowship can provide some of the foundation for performing and interpreting GI motility tests. Advanced training is also available in some centers. The involvement of the director varies from laboratory to laboratory. Typically, nurses/technicians can be trained to do the standard laboratory procedures, with the director performing the study interpretation (37).

BILLING AND CODING (UNITED STATES)

Coding regulations change regularly, and we have provided only a brief overview. Please refer to additional sources for the most up to date information.

Correct coding is essential to the sustainability of the endoscopy unit. There are codes for routine endoscopic procedures and more specific codes for different interventions (eg, colonoscopy with polypectomy via hot biopsy vs snare). When coding for multiple endoscopic procedures, a modifier code should be used (38). In Canada, billing is a provincial government function and thus each center should consult with their provincial health insurance plan Schedule of Insured Fees for billing endoscopy.

The correct CPT code for upper endoscopy with biopsies is 43239 and that for upper endoscopy with esophageal dilation is 43249. A foreign body removed from the upper GI tract is 43247 and upper endoscopy with banding of esophageal varices is 43244 (please refer to Table 7 for CPT codes according to listed procedure) (39,40).

TABLE 7. CPT Codes for endoscopic procedures

Procedure	CPT code	Description
Upper endoscopy	43235	Diagnostic EGD to duodenum/jejunum
Upper endoscopy with submucosal injection (s)	43236	Any substance
Upper endoscopy with biopsy	43239	
Upper endoscopy with sclerosis of esophageal varices	43243	
Upper endoscopy with band ligation of esophageal varices	43244	
Upper endoscopy with foreign body removal	43247	
Upper endoscopy with balloon dilation (<30 mm diameter)	43249	Dilation other than achalasia
Upper endoscopy with control of bleeding	43255	Any method
Upper endoscopy with endoscopic ultrasound	43259	
Upper endoscopy with pneumatic dilation for achalasia	43458	
Upper endoscopy for percutaneous gastrostomy tube	43246	
Small intestinal endoscopy, enteroscopy	44360	
Enteroscopy with biopsy	44361	
Enteroscopy with removal of foreign body	44363	
Enteroscopy with control of bleeding	44366	
Flexible sigmoidoscopy	45330	
Flexible sigmoidoscopy with biopsy	45331	
Flexible sigmoidoscopy with removal of foreign body	45332	
Flexible sigmoidoscopy with control of bleeding	45334	
Flexible sigmoidoscopy with directed submucosal injections	45335	
Flexible sigmoidoscopy with dilation by balloon	45340	One or more strictures
Colonoscopy	45378	
Colonoscopy with biopsy	45380	
Colonoscopy with directed submucosal injections	45381	
Colonoscopy with removal of foreign body	45379	
Colonoscopy with control of bleeding	45382	
Colonoscopy with removal of polyps by hot biopsy forceps	45384	
Colonoscopy with snare polypectomy	45385	
Colonoscopy with dilation by balloon	45386	One or more strictures
Percutaneous liver biopsy	47000	
Rectal suction biopsy	45100	
Anorectal manometry	91122	
Biofeedback	90911	
Esophageal motility	91010	
Capsule endoscopy interpretation	91110	
pH probe placement and analysis	91034	
pH and impedance probe placement and analysis	91038	
Change of gastrostomy tube	43760	
Endoscopic conversion of gastrostomy to jejunostomy	44373	
Percutaneous liver biopsy	47000	
Biliary endoscopy (ERCP)	47550	
ERCP with biopsy	47553	
ERCP with removal of calculus/calculi	47554	
ERCP with dilation of biliary stricture (s) without stent (s)	47555	
ERCP with dilation of biliary stricture (s) with stent (s)	47556	

ERCP = endoscopic retrograde cholangiopancreatography.

Appendix 1 reviews a few commonly used modifiers (Supplemental digital content, *http://links.lww.com/MPG/A623*). Many hospitals will bundle their facility fee charges for a combined case such as an EGD and colonoscopy with biopsy.

PEDIATRIC-SPECIFIC CONSIDERATIONS

In the United States, most pediatric endoscopy is performed by board certified pediatric gastroenterologists (41). It may, however, be that routine and advanced endoscopic procedures in pediatric patients are being performed by a variety of different providers and in different procedural environments (42). All providers performing endoscopy in children must recognize that the procedural environment requires specific modifications to ensure a safe and successful procedure (30). This includes modifications to the preprocedure, procedural, and recovering environments that take into consideration the unique aspects of pediatric care.

Preprocedural Considerations

In the preprocedural area, parents, legal guardians, and/or other family members nearly universally accompany pediatric patients. Care must be taken to design such areas to accommodate additional people as well as provide adequate areas to conduct preprocedural evaluations. Proper informed consent must be obtained from the parent/legal guardian, along with assent in the

case of older adolescent patients. Prolonged fasts without peripheral hydration may predispose young infants and children to dehydration; thus, efforts should be made to accommodate these patients with morning procedure times. It is also advised to provide patients undergoing endoscopic procedures access to a dedicated restroom large enough to accommodate both the patient and a family member for assistance. Restricting such a restroom for patients undergoing procedures ensures its availability when needed on an urgent basis as is frequently encountered in patients who have undergone bowel preparation or are undergoing motility procedures.

Preprocedural efforts should be made to reduce the anxiety and stress experienced by pediatric patients and their parents as this has been shown to reduce distress in the recovery and postprocedural phase. This can be accomplished through a variety of methods that may be used in combination, including preprocedural pharmacological anxiolytics, child life preparation and coping skills education, preprocedural tours of the procedural area, preprocedure video game exposure, and allowing family members to be present at the time of induction. The personnel attitude can also make for a more pleasant experience. Patients and families can be received in the preparation area by the endoscopist, anesthesiologist, and nurse. The available literature suggests there is not a one-size-fits-all methodology when it comes to designing preprocedural areas that reduce patient anxiety. Ensuring that appropriate resources are secured at the time of unit design allowing for a robust child life presence in the preprocedural area is important for the following reasons:

1. This will ease anxiety and provide distraction for the patient when the parent/caregiver is providing the medical history.
2. It will provide the parent/caregivers with an example of how to answer questions and provide feedback for the patient after the visit and before the procedure.
3. This will provide a familiar experience for the patient and family on the day of the procedure. In some cases the family and patient will meet the same providers for both visits which are ideal.
4. Distraction on the day of the procedure is also required and in some cases the family can be advised in advance of what to bring on the day of the procedure based on the patient's developmental age and needs.

In addition, thoughtful unit design will minimize the transport distance between the preoperative and main endoscopy areas, particularly when it requires separation from the patient and family members such as occurs when traversing sterile OR corridors.

Procedural Considerations

General principles have previously been published which help promote safe and effective procedures in the GI endoscopy unit and are applicable to patients of all ages (43). Although every effort should be made to select appropriately sized equipment before the start of each procedure, units should be designed so that access to scopes of different sizes, as well as their corresponding accessories, can occur in a timely manner in cases of an unforeseen scope/size mismatch. As routine biopsies of normal appearing mucosa during upper and lower endoscopy are still standard practice in the pediatric population, preparations should be made appropriate supplies are available during each case. Many advanced procedures such as EUS and ERCP require staff members other than the primary endoscopist to perform maneuvers that may be important for procedural success (eg, wire advancements and catheter exchanges). As these procedures are performed with decreased frequency in the pediatric population it is prudent to attempt to dedicate certain staff members to assist with such procedures so they can build an advanced competency. As some advanced endoscopic accessories are infrequently used in the pediatric population, forming a cooperative relationship with an adult unit where such supplies are used with greater frequency can provide the pediatric unit with a method of limiting the waste and cost associated with allowing such materials to expire and go unused. It may be useful to differentiate pediatric facilities committed to secondary or tertiary care as the staff expertise and equipment needs can vary. It is also important to consider hospital and sedation practices regarding thrombosis prevention, which may be a consideration in certain patient groups such as hospitalized patients with inflammatory bowel disease.

Pediatric endoscopy units must take care to recognize the physiologic differences between pediatric and adult patients, particularly as it relates to how sedation and analgesia will be administered during the endoscopic procedure. The AAP has previously put forth recommendations regarding minimum staffing and monitoring of children undergoing sedation for diagnostic and therapeutic procedures (44). The relatively high surface area of younger patients predisposes them to developing hypothermia, which can increase the need for thermoregulatory and respiratory interventions (45). Although most endoscopic procedures are of short enough duration that this may not be clinically relevant in most instances, the endoscopy area should have ready access to warmers as well as the ability to rapidly control room temperature. This may be particularly important in longer cases or those involving the youngest infants. Children also have proportionally higher oxygen consumption when compared to adult patients; thus, routine oxygen administration during pediatric procedures is seen as a low cost, high-benefit practice particularly because hypoxia represents the most common immediate adverse event following pediatric upper endoscopy (46). Although many gastroenterologists comfortably administer appropriate sedation and analgesia during their endoscopic procedure, endoscopists also frequently use the assistance of an anesthesiologist (47). There is also great variation in types and routes of sedation and analgesia administered in pediatric endoscopy (47). Regardless of the type of sedation administered and who is administering it, endoscopy rooms must be appropriately equipped with personnel and equipment that will allow for appropriate rescue maneuvers to be instituted to all size patients should the depth of sedation advance deeper than anticipated.

Postprocedural Considerations

Once deemed stable for transport out of the main endoscopy area, patients should be escorted to an appropriate postprocedural area to complete the recovery process. During transport, care should be taken to provide appropriate positioning of the head and neck of young infants to prevent airway obstruction. All patients should be appropriately monitored in a postprocedural recovery area until a time in which it is deemed safe for them to be discharged to the care of a supervising adult (44). In addition, providing a reasonable variety of age-appropriate choices to advance the diet in the postprocedural area will help meet the needs of the variety of patients who will be encountered. Finally, having a space that allows for the early reuniting of patients and family members in the postprocedural period can alleviate anxiety of family members and patients alike.

CONCLUSIONS

There is little literature describing an approach to designing the pediatric GI endoscopy unit. We believe this clinical report will help fill this gap and serve as a working reference document for those pediatric centers developing endoscopy programs. A

systematic review of the literature was undertaken in the preparation of this report, and the rich experience of the NASPGHAN Endoscopy and Procedures Committee members was also a critical component. Potential future directions include improving the patient experience and developing standardized processes to ensure the highest quality care.

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