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TOPIC HIGHLIGHT

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Colonoscopic polypectomy and associated techniques

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Abstract

Polypectomy of colonic polyps has been shown to reduce the risk of colon cancer development and is considered a fundamental skill for all endoscopists who perform colonoscopy. A variety of polypectomy techniques and devices are available, and their use can vary greatly based on local availability and preferences. In general, cold forceps and cold snare have been the polypectomy methods of choice for smaller polyps, and hot snare has been the method of choice for larger polyps. The use of hot forceps has mostly fallen out of favor. Polypectomy for difficult to remove polyps may require the use of special devices and advanced techniques and has continued to evolve. As a result, the vast majority of polyps today can be removed endoscopically. Since electrocautery is frequently used for polypectomy, endoscopists should be thoroughly familiar with the basic principles of electrosurgery as it pertains to polypectomy. Tattooing of a polypectomy site is an important adjunct to polypectomy and can greatly facilitate future surgery or endoscopic surveillance. The two most common post-polypectomy complications are bleeding and perforation. Their incidence can be decreased with the use of meticulous polypectomy techniques and the application of some prophylactic maneuvers. This review will examine the technique of polypectomy and its complications from the perspective of the practicing gastroenterologist.

Key words: Colonic polyp; Polypectomy; Colonoscopy; Polypectomy technique; Complications

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INTRODUCTION

Polypectomy is a fundamental skill utilized by all endoscopists who perform colonoscopy. Mastery of polypectomy is difficult and requires both significant experience and study. It is clear that polypectomy is efficacious in reducing the risk of colon cancer development by interrupting the adenoma to carcinoma progression[1,2]. Endoscopic techniques used in colonoscopic polypectomy continue to evolve, and it is important for all endoscopists to be familiar with these concepts.

Decision making about how to perform polypectomy is often made during colonoscopy when a polyp is detected. A general rule is that all potential adenomas should be removed. The endoscopic appearance of a polyp is often not necessarily a good indicator of its histologic nature. While as many as 70% of diminutive polyps (less

than 5 mm) may be adenomas, the risk of any particular polyp containing malignancy increases with the size of the polyp[3-6]. The method chosen for polypectomy is often related to the appearance and size of the polyp. Polyps are usually described as being pedunculated, sessile or flat. The risk of a polyp 2 cm in size or larger being malignant is greater than 10%[7]. Some polyps blur the lines though, by not falling into these strict categories. Nevertheless, consideration of polyp characteristics is helpful in determining the best approach to polypectomy[8].

COLD FORCEPS POLYPECTOMY

The simplest method for polypectomy is cold forceps removal. A survey of common practices among gastroenterologists found that cold forceps polypectomy was the technique of choice for small polyps, particularly polyps 1 to 3 mm in size[9]. In slightly larger polyps, jumbo forceps could be considered. Cold forceps can easily grasp small polyps that otherwise might be too small to snare.

After passing the forceps through the channel, the forceps and the scope can be manipulated in order to grasp as much polyp tissue as possible. Turning the scope to bring the polyp to the five to seven o'clock position can be useful since that is the position at which the forceps exit the endoscope channel. After closing the forceps on the polyp, a gentle pull on the wire removes the bite of polyp from the colon mucosa. The area is examined to determine if further bites are necessary to complete polyp excision.

Advantages to cold forceps polypectomy include avoiding risk associated with electrocautery and an almost negligible risk of colonic perforation[10]. One challenge associated with cold forceps polypectomy is that after the initial bite, minor bleeding can obscure the polypectomy field increasing the risk of leaving residual polyp behind[11].

HOT FORCEPS POLYPECTOMY

Hot forceps polypectomy is another option for small polyps. Hot forceps polypectomy is similar to cold forceps except it uses electrocautery to try to destroy residual polyp tissue intentionally left behind[12]. In hot forceps polypectomy, only the tip of the polyp is grabbed in the forceps. The small polyp is pulled into the colon lumen to create a tent-like effect and electrocautery is applied to destroy the polyp base while preserving the polyp tissue inside the forceps as a histological specimen[13].

Over the years, the use of hot forceps has fallen out of favor. One randomized study by Ellis looked at 72 polyps 6 mm or less in size and found that hot forceps still left residual polyp tissue behind 22% of the time compared to only 5%-14% of the time with either cold or hot snare[14]. Another study by Peluso retrospectively looked at 62 hot forceps polypectomies for polyps 3-6 mm in size and found that 17% of the time residual polyp tissue remained on follow-up endoscopic exam 1 to 2 wk later[15]. Cold forceps and snare polypectomy have been described as having a 16% residual polyp rate which suggests that hot forceps are either no better or even worse than other accepted methods of polyp removal. Hot forceps may still be useful though for small polyps that have a tip easily grasped with forceps but a polyp base that is hard to reach yet could still be destroyed with application of electrocautery.

SNARE POLYPECTOMY

Snare polypectomy was found to be the preferred method for removal of polyps 1 cm or greater in size in a survey of common gastroenterology practices[9]. A snare is a self-contained metal ring that is opened over the polyp and then closed entrapping polyp tissue for resection by closing the ring. Before pulling the snare out of the scope, the polyp should be brought to the six o'clock position. Sometimes advancing the snare proximal to (beyond) the polyp is useful if the polyp is behind a fold or inclined to flop out of the opened snare. The snare can also be used to position a pedunculated polyp in such a position as is more amenable to capturing once the snare is opened. Once the polyp is captured in the snare, the snare plastic sheath should be advanced moving the polyp away from the scope tip if electrocautery is to be used to avoid electrical damage to the scope. When snaring a pedunculated polyp, the snare should be placed about half way up the stalk, so that after cutting, a stalk remnant is left which can be grabbed or clipped if hemorrhage occurs. The polyp is pulled away from its base into the lumen tenting the colon wall to avoid burning the adjacent deep colon layers[11].

A snare can be either hot or cold in that it can be supplemented with electrocautery or not. During hot snaring, the endoscopist's assistant should close the snare slowly and gently. If the snare is too tight prior to electrocautery application, it could result in inadvertent cold cutting the polyp, resulting in bleeding from the stalk or in the snare becoming entrapped into coagulated tissue in the stalk[16]. Once the snare is in position, a few seconds of electrocautery can be applied if opted for, and then the endoscopist instructs the assistant to cut through the polyp.

There are many different types of snares each with specific advantages which can be chosen depending on the situation. Oval and hexagonal snares are most commonly used. We suggest using a barbed snare for hard to grab tissue as can be the case in flat or sessile polyps or when the snare slipping off the polyp seems to be a problem. Crescent snares are often used in EMR. A rotatable snare is useful when initially the snare comes out of the scope in such a way that is not optimal for snaring the polyp and it is desirable to rotate the snare to an angle that is better for capturing the polyp. A mini-snare can be used for cold snaring smaller polyps or to remove a small amount of residual tissue after piecemeal polypectomy[17]. There is a combination snare-injection needle which allows for quick injection prior to opening the snare and avoids having to change out an injection needle wire for

the snare (i-Snare system, US endoscopy, Mentor, Ohio, USA)[18].

ELECTROCAUTERY

The purpose of electrocautery in polypectomy is to either provide extra power in cutting tissue or to prevent bleeding by coagulation of tissue. The basic principle in electrocautery is that if enough electrical current is delivered, heat will be generated to cause cellular bursting leading to tissue cutting. If somewhat less heat is generated then cell shrinkage leading to tissue coagulation occurs. Even pure cut current causes some coagulation, and pure coagulation current has some cutting property. Snares and hot forceps use monopolar electrocautery, which means that the electrical circuit runs through the patient body to a grounding pad placed on the patient. Cautery probes can also use bipolar electrocautery, which means that the electrical circuit runs between two electrodes both located on the tip of the probe. Energy deliverance is also proportional to the time it is applied, so the length of time the endoscopist keeps their foot on the pedal is very important[16]. The use of coagulation current has been associated with more delayed post-polypectomy hemorrhage, whereas the use of cutting and blended current have been associated with more immediate hemorrhage[19]. A review of electrocautery by Morris suggests using coagulation at a setting of 20 Watts for hot snaring. Since cut has also been associated with a higher risk of perforation, we suggest first using coagulation for standard colonoscopic snare polypectomy. Then after using coagulation, the endoscopist can consider using some cut function next if the polyp has a thick stock and coagulation alone is unable to cut through it or in the case that the snare becomes entrapped on the polyp stock. For hot forceps electrocautery coagulation at 10-20 Watts can be used[16]. Most modern electrosurgical units have preset polypectomy settings.

LARGE POLYPS

In the past, large polyps often required surgery for removal, but now many can be managed endoscopically[20]. Endoscopic Mucosal Resection (EMR) can be performed on sessile polyps 2 cm in size or larger. EMR involves submucosal injection (often of saline) creating a cushion for the polyp and then hot snaring the polyp either *en bloc* (all together) or piecemeal (multiple snarings). EMR can provide resection down to the muscularis propria[21-23]. There is no official distinction between saline assisted piece meal polypectomy and EMR but typically the term polypectomy is reserved for removal of flat lesions measuring less than 2 cm and the term EMR is used for larger lesions[4,24]. Endoscopic Submucosal Dissection aims to remove all dysplastic tissue en-block as one piece rather than the piecemeal technique that is used with saline assisted polypectomy and EMR[25]. Large polyps are often adenomatous, therefore complete resection is the goal even though it is often time-consuming. Iishi found that 55% of polyps resected in piecemeal fashion required further resection on a repeat colonoscopy, but complete resection was possible in 83% of polyps after up to three repeat colonoscopies[26]. Flat and sessile polyps can be challenging to snare as they are often level with the colon floor. The first piece of tissue snared can leave divots or ledges in the remaining polyp that can make it more easily grabbed in subsequent snares. If residual polyp tissue is left after piecemeal polypectomy, argon plasma coagulation (APC) can be used to tryw to destroy the residual tissue[27]. After any piecemeal polypectomy, the site should be re-examined in 2 to 6 mo to evaluate for any residual polyp tissue[7,8].

POLYP RETRIEVAL

Once polyp tissue is snared, actually retrieving it can be challenging. Many endoscopists periodically experience the frustration of successfully snaring a large adenoma-appearing polyp only for it to fall out of view or get lost in the colon somewhere[28]. However, even experienced endoscopists may fail to retrieve polyp tissue up to 16% of the time[8]. Possibly the most common way to retrieve a polyp once it is snared is to drive the scope up to the polyp in the six o'clock position and then to suction the polyp through the scope into a trap, using a back flush if needed. If the polyp is too big to be suctioned into the scope, the snare can be used to cut the large polyp into pieces small enough to fit through the suction channel. Polyp tissue can also be grabbed with forceps while the entire colonoscope is withdrawn. In these cases the forceps can be advanced out a few centimeters so that simultaneous examination of the remaining colon can be performed while the specimen is kept in view. A Roth net can be used to remove large polyps or several polyp fragments at once. Also, an overtube can be used for easy repeated colonoscopic intubation to the polypectomy site with repeated removal of polyp fragments[29,30].

RESIDUAL POLYP TISSUE

Leaving residual polyp tissue behind leaves behind cells that may continue to progress through the adenoma to carcinoma sequence, therefore the purpose of polypectomy is to break that sequence. Risk of residual polyp tissue is often the outcome measured in studies comparing different methods of polypectomy, such as snare *vs* forceps. In an observational study, Tappero *et al*[17] found that a snare never left behind residual polyp tissue but cold forceps often did. Zlatanic found that for treating residual tissue, piecemeal polypectomy left behind residual tissue 46% of the time, APC destruction still left residual tissue 50% of the time, and doing nothing left behind residual polyp obviously 100% of the time[24].

THE CHALLENGING POLYPECTOMY

Some polyps provide distinct challenges that call for utilizing other approaches than just standard polypectomy techniques. Endoscopists periodically find polyps that

are very difficult to remove. These can include polyps that are located behind colon folds, polyps that are very large, polyps that are just out of reach, and flat, carpeted, or thick polyps. For polyps hiding behind folds and large pedunculated polyps, Valentine *et al*[31] described a technique using a double channel therapeutic endoscope. A tripronged grasper is advanced *via* one of the channels to pull the polyp into better view and into the snare, while a snare for polypectomy is inserted through the other channel. A standard upper endoscope can also be considered for difficult to reach polyps as it has a tip with a tighter bending angle than a colonoscope[32]. A side viewing scope can be used for polyps that are behind folds or on a side of the colon wall unable to be reached by a standard colonoscope. Friedland[33] described either retroflexing the colonoscope or injecting a large amount of saline proximal to the lesion as options to try to reach polyps on the inside wall of tight turns. Even two different scopes manipulated by two endoscopists can be attempted with one scope grabbing the polyp and pulling it into a convenient location while the other scope performs polypectomy has been described[8]. Colon spasms can present a challenge by constantly moving the polyp in and out of view, and glucagon can be given intravenously to decrease these spasms[8]. Some polyps may not be amenable to endoscopic polypectomy and are better served with surgery. If a large polyp is in the cecum, extends into the ileocecal valve, or extends into the appendix, surgery may need to be considered. Also polyps that involve more than 30% of the colon circumference are often impossible to remove endoscopically[11].

Injection

An important related tool to consider for polypectomy is injection with either saline or epinephrine (1:10000) into the polyp base or stalk. The submucosa is the target location for fluid deposit, so the endoscopist should try not to penetrate the colon wall with the needle. Injected fluid can diffuse fast, so sometimes repeat injections are needed. Injection is suggested in the literature for larger polyps specifically. Most studies looking at resection of large or giant polyps include epinephrine injection in their polypectomy protocol. Injection can lift up flatter polyps rendering them more polypoid and more amenable to snare polypectomy and complete resection[34]. The injected fluid may also serve as a safety cushion by increasing the distance between the mucosa and the muscle layer and serosa, thereby at least theoretically decreasing risk of perforation[21,35]. If a polyp does not lift with an appropriate injection technique it may be caused by an underlying cancer extending to deeper colon layers. Pedunculated polyps with large stalks are more inclined to bleeding. Injecting these large stalks before snare polypectomy may provide prophylactic hemostasis and reduce the risk of a post-polypectomy bleed. Epinephrine is a potent vasoconstrictor, and both saline and epinephrine can exert a tamponade effect on blood vessels[36]. A study by Dobrowolski randomized 100 polyps to either epinephrine injection or no injection and found one post-polypectomy bleed in the injection group compared to 8 bleeds in the no injection group[37].

Endoloops

In addition to injection, another option for prevention of post-polypectomy bleed is an endoloop[38]. The endoloop is a detachable oval-shaped nylon snare. It is deployed in the same way as a standard snare but then tightened and released around the stalk or base of the polyp prior to polypectomy. A gastroenterology survey showed that 38% of endoscopists report using endoloops[9]. A trial done in Greece by Kouklakis randomized 64 patients with polyps greater than 2 cm in size to get either epinephrine injection or a combination of endoloop and endoclip placement. The combination endoloop and clip group did significantly better with only 3% post-polypectomy hemorrhages compared to the epinephrine group which had a 12% rate of post-polypectomy hemorrhage[39]. The Di Giorgio study found a lower rate of post-polypectomy bleed at 1.8% with a detachable snare compared to 3% for epinephrine injection and 8% for no prevention[40]. In 152 snare polypectomies, Paspatis *et al*[41] found that combination epinephrine injection with endoloop placement was associated with only a 1% rate of delayed bleeding whereas epinephrine used alone was associated with an 11% rate of delayed bleeding. However many problems with endoloops such as slipping off the polyp stalk, inadequate tightening, and persistence of bleeding despite endoloop placement were described in a retrospective study by Matsushita *et al*[42].

Tattooing

Large or polyps suspicious for invasive cancer should be considered for tattooing for easier future localization either by a surgeon during colectomy or by an endoscopist during future surveillance colonoscopy[43,44]. Endoclip placement and inter-operative colonoscopy are other ways to re-identify a lesion, however the endoclips can slip off prior to surgery, and inter-operative colonoscopy can be cumbersome and time-consuming. India ink is the preferred identification agent for tattooing polyps[45] because the ink is phagocytosed by macrophages giving the site an almost permanent easily detected marking. Other dyes like indigo carmine and methylene blue are too rapidly resorbed to be useful. Commercially available India ink is a sterile carbon based dye suspended in stabilizing particles and diluted in normal saline to a 1:100 concentration[46]. India ink is injected through an injection needle and targeted to the submucosal layer of the inter-haustral folds. Common practice is to place a tattoo on more than one side of the lesion in either a two or a four quadrant manner. Injecting at an oblique angle tangential to the colon wall can avoid penetration of the colon wall which can result in inflammation and a diffuse staining of the peritoneum thereby obscuring the surgeon's view during operation[44,47]. To ensure proper ink placement, a double injection technique has been described in which 1 mL of saline is first injected creating a submucosal bleb[48]. Once the

saline bleb is made, the needle is left in place, the saline syringe is changed to an India ink syringe and about 0.1 to 2 mL of tattoo ink is then injected into the bleb space[49,50]. After tattooing the polyp site, the endoscopist should also include in the report the distance of the site from the anal verge in centimeters to aid in future localization.

ENHANCED POLYP DETECTION AND CLASSIFICATION TECHNIQUES

Standard colonoscopy based on white light may have a polyp miss rate of anywhere from 1% to 26%[51]. Also distinguishing truly neoplastic lesions from normal or benign tissue endoscopically can be challenging. Potentially unnecessary biopsies require pathologic evaluation leading to increased costs, so one advantage of enhanced detection techniques includes avoiding this increased cost[52]. Some newer modes of enhanced polyp detection and classification have been developed over the last few years. High definition colonoscopy, chromoendoscopy, and narrow band imaging (NBI) are useful to enhance polyp detection. Confocal Laser Endoscopy, and spectroscopic colonoscopy are more for enhancing polyp classification.

High definition colonoscopy (complete system can cost $215 000 from Olympus America, Center Valley, PA, USA) provides an image containing more pixels and better picture quality than standard definition colonoscopy. One retrospective study by Buchner showed a significantly higher polyp and adenoma detection rate (4%-5% increase in yield) with high definition colonoscopy compared to standard definition colonoscopy for polyps less than 1 cm and in the left colon[53].

Another enhanced detection technique, chromoendoscopy, uses indigo carmine (25 g costs about $40) that is flushed over the colonic mucosa to demarcate polyp architecture, vascular pattern and pit detail. This can highlight subtle differences between normal colonic tissue and polyp tissue making polyp detection easier. NBI, a type of virtual chromoendoscopy, is another enhanced mode that uses special narrow band filters to enhance surface and vascular pattern appearance of potential polyps. NBI may be useful for distinguishing between hyperplastic and adenomatous polyps as well. One study from Japan looked at NBI in the evaluation of 617 colorectal lesions and reported a sensitivity of 90.9% and a specificity of 97.1% for differentiating non-neoplastic from hyperplastic lesions[54]. Round and stellate pit patterns represent benign lesions, and villiform, gyrus-like, and irregular patterns represent neoplastic lesions. Many standard colonoscopies now have NBI capability (which means no additional cost to patients when it is used) which is activated by pushing a button on the head of the scope[55,56].

A new spectroscopic probe (not commercially available yet) has been developed that detects the increased microvascular blood supply in normal tissue at the periphery of a polyp that may be unseen or behind a fold. This alerts the endoscopist "like a metal detector going off" to examine the nearby mucosa more carefully to find the polyp thereby increasing detection[57].

Confocal laser endoscopy (CLE) is an enhanced mode of polyp classification (Cellvizio, Paris, France). Once a potential polyp is endoscopically detected, the lesion is focused on for analysis to determine if it is benign or neoplastic. Thousands of optical fibers bundled together take 12 pictures per second and provide image resolution detailed to the micron level. Pit pattern, crypt architecture, and vascular patters are analyzed; and irregular vessels, presence of mucin and increased tissue density indicate a neoplastic lesion. CLE is either integrated into the scope or used as a separate probe passed through the accessory channel[58]. A study from Mayo Jacksonville found CLE to have a sensitivity of 76% and a specificity of 72% in differentiating non-neoplastic from neoplastic lesions. Interobserver agreement over what the images represented was found to be 78%[59].

HEMORRHAGE

Even though the benefit of polypectomy is significant in terms of reducing the risk of colon cancer development, polypectomy is not without some risk of complications. Most complications are related either to post-polypectomy hemorrhage or perforation. Hemorrhage is the most common and is usually divided into immediate (less than 12 h post-procedure) and delayed (after 12 h post-procedure but up to 30 d). There is a greater risk of immediate hemorrhage associated with cut or blended electrocautery and a greater risk of delayed hemorrhage with the use of coagulation current. These specific risks should be appreciated and weighed when choosing electrocautery type.

Dobrowolski *et al*[60] noted that the risk of post-polypectomy hemorrhage ranges from 0.3% to 6% but can be as high as 24% in large polyps. He found that hemorrhage was more likely in polyps larger than 17 mm, pedunculated polyps with stalks thicker than 5 mm, sessile polyps, and malignant polyps. Watabe found that hypertension also puts patients at risk for a delayed post-polypectomy hemorrhage[61].

Immediate hemorrhages are frequently noticed during colonoscopic examination as bleeding from the polypectomy site is directly visualized. In these cases, either epinephrine injection into the base of the polypectomy site or endoclip placement is often considered as first line hemostatic therapy. Endoloop placement can also be considered and applied either to a stalk or to a larger polypectomy base for hemostasis. If snaring a pedunculated polyp results in a visibly bleeding stalk, sometimes grasping the stalk with the snare and holding pressure for 5 min can stop the hemorrhage[36].

Endoclips can be placed onto a bleeding residual stalk or empirically placed just lateral to the polypectomy site to tamponade any supplying blood vessels[62]. Endoclips can also be placed prophylactically at the polypectomy site after removal of the polyp. A group in Spain looked retrospectively at 34 polypectomies using endo-

clips either before or after resection of polyps 15-40 mm in size with stalks 5-12 mm in thickness. They found that all episodes of bleeding could be controlled with the use of endoclips. They also found that the clips easily catch stalks around 5 mm in thickness but that two clips could be placed on stalks thicker than that[63].

Friedland *et al*[64] described performing polypectomy on polyps less than 1 cm in size in actively anticoagulated patients. He placed endoclips prophylactically at the polypectomy site and had no more incidence of post-polypectomy bleed than in non-anticoagulated patients.

Many forceps polypectomies result in some minor oozing from capillaries at the polypectomy site, and this is usually self-limited and resolves after continued visualization. Delayed hemorrhage can require hospitalization, blood transfusion, and repeat colonoscopy for definitive hemostasis.

PERFORATION

Perforation is a serious complication that can result from polypectomy and can often have major clinical ramifications for the patient after the procedure is over[65]. Factors contributing to perforation include mechanical stress from the scope, barotrauma, electrocautery, and the depth of the polyp resection itself. The risk of perforation with all colonoscopies has been estimated somewhere around 1 perforation per 1000 to 2000 colonoscopies[66-68]. Risk of perforation however increases in polypectomies involving longer electrocautery time, removal of larger polyps, location in the cecum, and large sessile polyps requiring piecemeal removal.

If a perforation is visualized during the procedure itself, the endoscopist can consider an attempt at closure with endoclips. The progress of Natural Orifice Translumenal Endoscopic Surgery research has highlighted the reality of closing a perforation endoscopically with endoclips[69]. However, emergency computed tomography imaging, antibiotic administration, bowel rest and surgical consultation still play an important role. Unfortunately, approximately 5% of perforations result in patient death[11].

Similar to perforation but less serious is post-polypectomy syndrome, another complication where there is a transmural burn not resulting in perforation. Post-polypectomy syndrome presents with leukocytosis, fever and abdominal pain in the absence of free air on imaging. Treatment of post-polypectomy syndrome is usually conservative involving antibiotics, fluids, and bowel rest[8].

CONCLUSION

In summary, colonoscopic polypectomy is a continuously evolving therapy that has been remarkable at reducing the risk of colorectal cancer. Gastroenterologists must be thoughtful and proficient in techniques such as snaring, injection, tattooing, and all other tools related to polypectomy for endoscopic success. Cold forceps seem to be preferred for small polyps and snares for larger. Coagulation current may be the electrocautery mode of choice for polypectomy, although it is associated with higher risk of delayed hemorrhage. Difficult to reach polyps continue to require various endoscopic tricks and an ability to improvise for successful resection. There are several options for prevention of bleeding in large polyps including injection, endoloops, and endoclips. Many complications can actually be managed endoscopically. On the research stage, there is still a shortage of studies about many specific aspects of polypectomy, and there is a significant need for more quality studies in the future.

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