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## Spinal Cord Injury Rehabilitation

For more than 40 years, Mayo Clinic has served individuals with spinal cord disorders through its comprehensive Spinal Cord Injury (SCI) Program. About 140 to 150 people with spinal cord dysfunction are treated in the acute rehabilitation unit yearly, with trau-



**Figure 1.** Research has demonstrated the effectiveness of body weight support treadmill training to improve quality and technique of walking.

matic SCI accounting for 15 to 20 percent of those served.

Mayo Clinic physiatrists who provide care for patients with SCI have supportive, collegial, and cooperative relationships with surgeons, oncologists, neurologists and multiple other medical specialists and subspecialists throughout Mayo Clinic. This collaboration, as well as Mayo Clinic's integrated medical record, enhances communication and supports timely, efficient patient care. Beyond creating a smooth-running system, this care model produces measurable patient outcomes.

The need to prevent complications in patients with neurogenic bladder, for example, illustrates the benefits of this multi-specialty collaboration. Only decades ago, neurogenic bladder problems were the No. 1 cause of mortality among SCI patients. Working with colleagues in urology, Mayo Clinic physiatrists

### Points to remember

- A unique collaborative model of care and integrated medical record help Mayo Clinic rehabilitation staff work with other specialists to identify and prevent potentially serious problems.
- Mayo Clinic's acute rehabilitation unit serves one of the largest populations of nontraumatic spinal cord injury patients in the United States. Despite the extreme complexity and severity of spinal cord impairment and the large array of comorbid conditions present in these patients, more than 77 percent of patients discharged from Mayo Clinic's acute rehabilitation unit return to their homes.

have found that implementing a system that uses more extensive monitoring, assessment and feedback has helped them diagnose bladder problems earlier and prevent the onset of serious neurourologic complications. The SCI program in Rochester, Minn., now has neurourologic rounds where staff meet and discuss cases on a regular basis and provide close follow-up, all of which have greatly reduced the incidence of these problems.

Patients with traumatic SCI have access to a broad array of coordinated, specialized care designed to help each individual reach his or her optimal functional ability, level of wellness, quality of life and re-entry into the community. Mayo Clinic's spinal cord system of care often begins with a preoperative outpatient consultation and continues through the acute hospital and rehabilitation settings, a subsequent comprehensive interdisciplinary coordinated outpatient program, and lifelong follow-up.

The initial phase of treatment focuses on compensatory strategies and education to re-establish basic life skills of self-care activities; mobility, transfers and gait; and learning to live a fulfilling life. In addition to the compensatory strategies, new restorative interventions also are used to achieve the highest possible functional outcome. These interventions may include functional electrical stimulation for upper and lower extremity function, bio-feedback, and locomotor training, including robotic-assisted locomotor (Lokomat) training and over-ground ambulation with or without body weight support (Figure 1, see page 1). More than 20 occupational and physical therapists skilled in SCI treatments and technology support these innovative services.

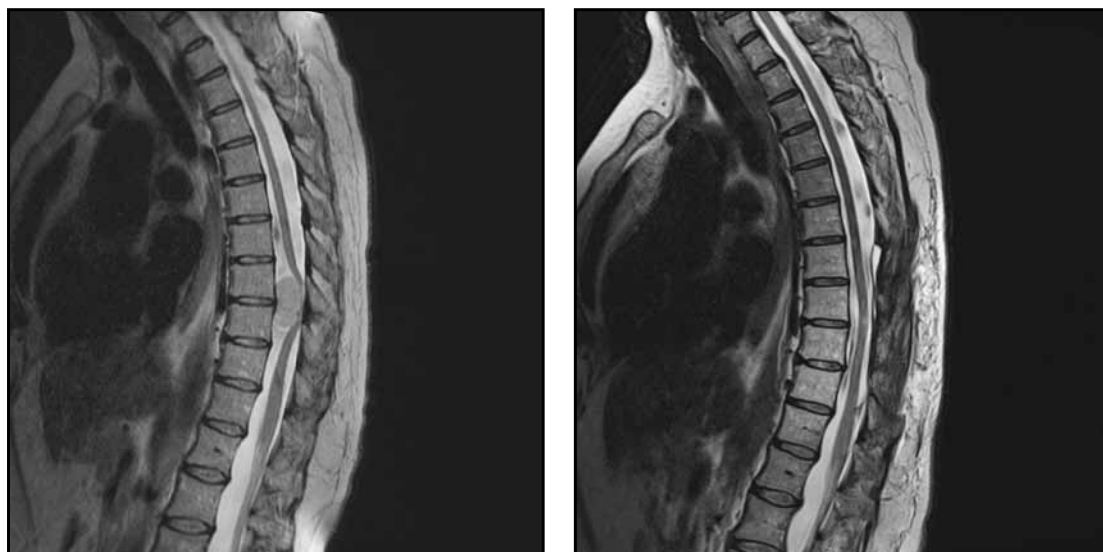
### Treatment of patients with nontraumatic spinal cord dysfunctions

Each year, about 100 to 120 patients with a diagnostically diverse array of nontraumatic spinal cord dysfunctions (NTSCDs) travel to Mayo Clinic from all over the world. This group of patients includes those diagnosed with unresectable vascular malformations, sarcomas and other tumors that cause cervical, thoracic, lumbar or sacral spinal cord dysfunction. Many of these patients have secondary complications similar to those associated with traumatic SCI, but they also tend to have additional comorbid conditions (Figure 2).

Patients with NTSCD are seen and treated in the acute hospital by the SCI team and also benefit from Mayo Clinic's unique model of care. Using a well-defined process to identify patients early as candidates for comprehensive inpatient rehabilitation allows staff to decrease the time between symptom onset and rehabilitation admission.

According to Mayo Clinic physiatrists, this coordinated process also helps yield excellent outcomes for patients with NTSCD served in the comprehensive acute rehabilitation program. Once admitted, these patients have exhibited greater than average functional changes, based on the Functional Independence Measure, and shorter than average lengths of stay. As a result, many patients have a greater level of independence on discharge.

Despite the extreme complexity and severity of the spinal cord impairment and large array of comorbid conditions present in these patients, more than 77 percent of the patients with NTSCD who are discharged from Mayo Clinic's acute rehabilitation unit return to their homes.



**Figure 2.** MRIs showing meningeal tumor before and after surgical resection.

# Percutaneous Repair of Paravalvular Prosthetic Regurgitation

## Points to remember

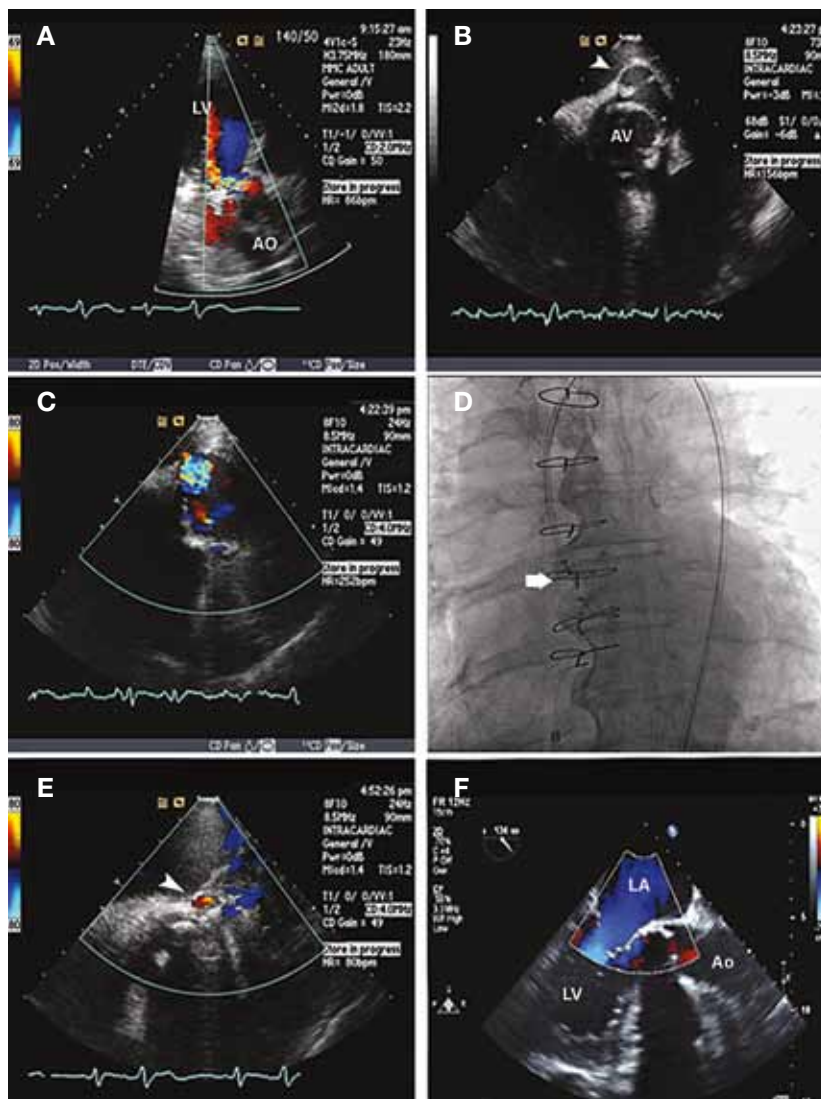
- Anatomic or technical factors, as well as associated surgical morbidity and mortality, can make operative repair of prosthetic regurgitation challenging.
- Percutaneous approaches to the treatment of paravalvular prosthetic regurgitation use a variety of complex catheter techniques to deliver occluder devices to the site of paravalvular prosthetic regurgitation.
- In the hands of experienced operators, defects involving mechanical or biological prosthetic valves can be treated percutaneously, with procedural success rates of about 90 percent and a low risk (< 5 percent) of complications.

Surgical placement of a cardiac prosthetic valve improves cardiovascular symptoms and, in many patients, is a lifesaving procedure. In 3 to 6 percent of patients, however, paravalvular prosthetic regurgitation occurs and may lead to heart failure or hemolytic anemia. Traditionally, the treatment of symptomatic paravalvular prosthetic regurgitation has been open-heart surgery. Operative repair may be challenging owing to anatomic or technical factors that led to the development of the prosthetic regurgitation, in addition to the associated surgical morbidity and mortality.

As a less invasive alternative, percutaneous approaches to the treatment of paravalvular prosthetic regurgitation have been developed. These percutaneous approaches use a variety of complex catheter techniques to deliver occluder devices to the site of paravalvular prosthetic regurgitation. Among experienced operators, defects involving mechanical or biological prosthetic valves can be treated with procedural success rates of about 90 percent and a low risk (< 5 percent) of complications, according to Mayo Clinic interventional cardiologists.

## Who is a candidate?

The Cardiac Catheterization Laboratory at Mayo Clinic in Rochester has been a leader in percutaneous repair of paravalvular prosthetic regurgitation, with nearly 200 patients having undergone the procedure to date. Experienced echocardiologists and interventionalists in

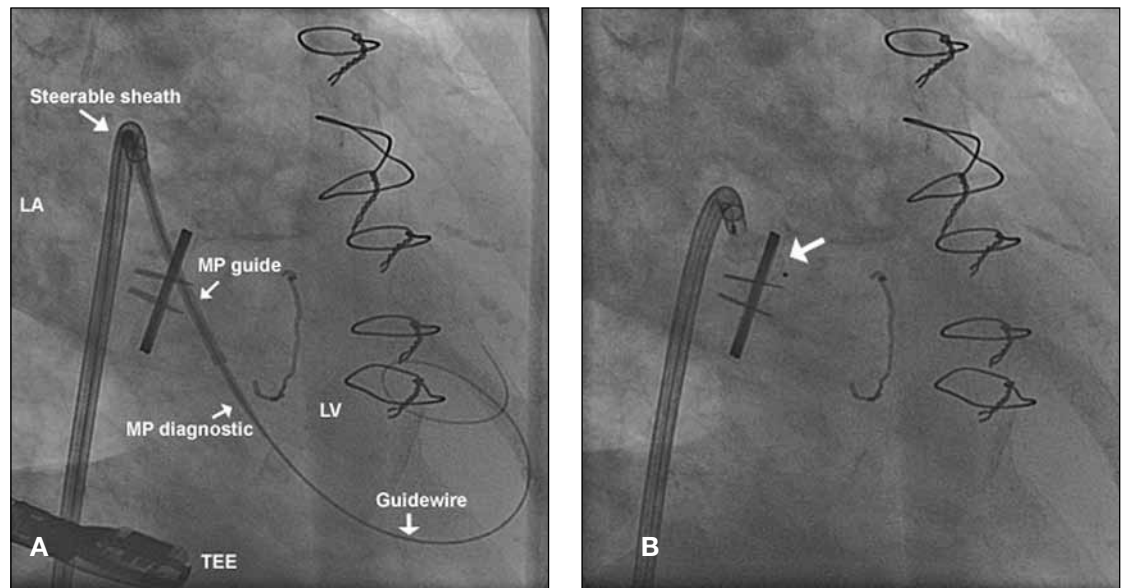


**Figure 1.** Percutaneous repair of paravalvular aortic prosthetic regurgitation. (A), Transthoracic echocardiogram showing severe paravalvular regurgitation involving an aortic bioprosthesis. (B) and (C), Intracardiac echocardiography showing the paravalvular defect (arrowhead in B) and regurgitation anterior to the valve prosthesis. (D), Using a retroaortic approach, a 12-mm vascular plug (arrowhead) was placed across the defect. (E), Immediately following placement of the device, there was minimal central regurgitation (arrowhead). (F), Transesophageal echocardiogram two months after the procedure shows complete cessation of the paravalvular prosthetic regurgitation. AO indicates aorta; LA, left atrium; LV, left ventricle.

dedicated specialty clinics evaluate patients with paravalvular prosthetic regurgitation routinely. Candidates for percutaneous repair are patients with one or more of the following:

- Moderate or severe paravalvular prosthetic regurgitation
- Symptoms of dyspnea
- Hemolytic anemia
- Absence of active endocarditis





**Figure 2.** Percutaneous repair of paravalvular mitral prosthetic regurgitation. A, An 8.5F steerable sheath is used to engage the defect with a 5F multipurpose diagnostic catheter telescoped through a 6F multipurpose coronary guide catheter. B, With the guidewire across the defect, a 16-mm vascular plug (arrow) is placed into the left ventricle and brought back to the site of paravalvular defect under fluoroscopic and echocardiographic guidance. LA indicates left atrium; LV, left ventricle; MP, multipurpose; TEE, transesophageal echocardiography.

Informed consent is obtained following a detailed discussion about the risks of the procedure and the option of reoperation, which frequently includes consultation with cardiovascular surgery colleagues.

### How the procedure is performed

In a patient with paravalvular regurgitation involving an aortic prosthesis, the defect typically is engaged using a retrograde approach from the femoral artery (Figure 1). For patients with mitral defects, transeptal access to the left atrium is obtained from the femoral vein, followed by placement of a steerable sheath. The deflectable tip of this sheath allows antegrade engagement of the mitral defect (Figure 2).

Once a prosthetic defect is crossed with a guide wire, a telescoped coronary guide catheter or a long delivery sheath is advanced, followed by placement of an appropriately sized occluder device in the defect. Echocardiography, which is essential, guides the procedure and allows its completion without the need for contrast. The occluder is released at the site of the paravalvular defect after demonstration of considerable reduction in the regurgitation, stability of the device and no interference with the prosthetic valve. Due to the serpiginous, calcific nature of some paravalvular defects, special techniques may be needed to pass delivery catheters. In these instances, an

arteriovenous rail can be created, in which a guide wire is snared in a distal chamber and exteriorized. For patients with two left-sided mechanical prostheses, this wire rail can also be created by exteriorizing the wire through the left ventricular apex via direct left ventricular puncture. The operator then uses both ends of the rail to provide support for passage of a delivery catheter across the paravalvular defect.

Paravalvular prosthetic defects may also be highly eccentric or crescent shaped. As a result, coverage of these types of lesions with a single large occluder may result in prosthetic interference from device overhang. In these cases, multiple devices with smaller diameters can be placed simultaneously using two delivery catheters or sequentially with an anchor-wire technique. Imaging with 3-D transesophageal echocardiography is helpful for examining the configuration of the defects to determine the potential need for these advanced catheterization techniques.

Given the potential for a less invasive alternative to open surgical correction, there has been great enthusiasm for percutaneous repair of paravalvular prosthetic regurgitation. Emerging techniques allow the routine use of this procedure in patient candidates and will continue to evolve to address this increasingly recognized complication of prosthetic valves.

## Predicting Outcomes in Normal-Pressure Hydrocephalus

Typically affecting older adults, normal-pressure hydrocephalus (NPH) is one of the more-difficult conditions to diagnose. In addition to gait difficulty and incontinence, the symptoms include cognitive impairment, which is often characterized as memory loss. The cause of enlarged ventricles, found on CT or MRI scanning, is uncertain. However, it has been shown experimentally to be associated with decreased absorption of spinal fluid; increased pulse pressure or systolic blood pressure (BP), or both; and brain atrophy. Mayo Clinic neurologists and neurosurgeons have a long experience in treating NPH and assessing factors that may predict outcomes.

### Diagnosis and treatment

After other causes of gait disturbance have been ruled out, patients at Mayo have a test that mimics a temporary shunt to determine whether decreasing cerebrospinal fluid volume improves gait. Typically, 30 cc of fluid is removed during a spinal tap, and pre- and post-procedure videos of the patient walking are compared. Separately, tests for cognitive function are conducted to help determine if memory problems are isolated or are accompanied by other impairments. The presence of aphasia, for example, suggests an additional degenerative pathology that likely will not improve with shunting.

Treatment consists of a neurosurgically placed shunt that drains cerebrospinal fluid into the peritoneal cavity. One of the known

### Points to remember

- Normal pressure hydrocephalus (NPH) is difficult to diagnose. After other causes have been ruled out Mayo Clinic neurologists use a test that mimics a temporary shunt.
- Treatment for NPH consists of a neurosurgically placed shunt that drains cerebrospinal fluid into the peritoneal cavity. Use of newer programmable shunt valves has improved outcomes and reduced the need for additional surgical procedures.
- Not all symptoms associated with NPH improve with treatment. Often, gait and incontinence improve, but memory and cognition may not.
- Mayo Clinic researchers are initiating a prospective study to determine whether the presence of amyloid in the brain influences cognitive outcomes from shunt surgery in NPH.

complications in the past has been overdrainage, which can cause the brain to shrink and may result in subdural hemorrhage or subdural hygroma. The recent introduction of programmable shunt valves, however, has improved outcomes and reduced the need for additional surgical procedures to adjust the rate of drainage (Figure). NPH may have a degenerative component. Even in patients with initial success, it may be necessary to adjust the rate of drainage six months to several years later. The programmable valve readily enables such adjustments and has made surgery more viable for more patients.

### Predicting cognitive outcomes

Not all symptoms improve with treatment. Often, gait and incontinence improve, but memory and cognition may not. Mayo neurologists suspect that overlapping conditions may be important to the cognitive decline associated with NPH. The presence of aphasia or even mild naming deficits may signal coexisting pathology, such as vascular disease or Alzheimer's disease (AD). Studies have shown that among people older than 74 years, the brains of more than 30 percent of patients show evidence of AD pathology on autopsy. Cerebrovascular disease also is frequent in this age group because hypertension is common. Several studies show that hypertension



**Figure.** CT scan of a patient with a subdural hygroma (arrow) and a shunt in place, illustrating overdrainage.

is associated with hydrocephalus in animal models and with hydrocephalus in humans.

### Related research

Mayo Clinic researchers analyzed data collected by the Atherosclerosis Risk in Communities (ARIC) Study, a prospective epidemiologic study sponsored by the National Heart, Lung, and Blood Institute. Looking at the MRI scans of study participants taken 10 years apart, researchers found that both increased systolic BP and increased pulse pressure correlated with increased ventricle size. In earlier research, Mayo investigators showed that head size also correlates with increased risk of NPH. Approximately 10 to 20 percent of people with NPH have a head size at or above the 98th percentile. Thus, it may be that people born with a large head have congenital hydrocephalus that becomes symptomatic as they age.

The question of the contribution of head size, vascular disease and underlying AD pathological factors is important to predicting outcomes for surgical shunting. To address these issues, Mayo researchers are initiating a prospective study in which 25 NPH patients who have agreed to shunt surgery will undergo neuropsychological tests and PET imaging to screen for amyloid-beta protein (A $\beta$ ) plaque buildup before surgery. They will also have gait evaluation and neuropsychological testing at one-year follow-up. The goal of the study is to determine whether the presence of A $\beta$  in the brain influences cognitive outcomes from shunt surgery in NPH. The investigators hope their findings will help physicians in counseling patients about which symptoms may improve with a shunt and whether shunting is a good option.

## A Multidisciplinary Approach to Bariatric Surgery

The devastating impact of obesity's rising prevalence is imminent, in terms of both the citizenry's health and the financial well-being of the health care industry. Major studies performed over the past few decades have found a clear correlation between obesity and the development of chronic metabolic conditions, such as type 2 diabetes mellitus, hypertension and hyperlipidemia. New data regarding structural changes to the heart itself also are being obtained and have demonstrated a direct correlation between left ventricular (LV) mass and BMI and fat mass. A recent study revealed that the LV mass doubles at a body mass index (BMI) of 50 kg/m<sup>2</sup> compared with a BMI of 20 kg/m<sup>2</sup>. Other studies also have shown associations between obesity and dementia (including Alzheimer's disease), obstructive sleep apnea, osteoarthritis and overall mortality rate. In fact, today's physicians may be seeing the first generation of individuals with a lower life expectancy than their parents.

Despite aggressive research efforts, a novel weight management drug without notable adverse effects is not on the horizon. On the contrary, recent data have forced the Food and Drug Administration to remove from the market many long-standing weight management agents, such as sibutramine, because of their adverse-effect profile. Bariatric surgery continues to be the most effective means of long-term weight management in people with medically complicated obesity, producing a resolution or improvement in many debilitating

### Points to remember

- The overall prevalence of obesity BMI  $\geq$  30 kg/m<sup>2</sup> in the United States is 33 percent and is expected to rise to approximately 50 percent over the next 20 years.
- Bariatric surgery continues to be the most effective means of long-term weight management in people with medically complicated obesity, resolving or improving many debilitating and life-threatening medical problems, as well as substantially improving quality of life.
- Several operative procedures, including sleeve gastrectomy, Roux-en-Y gastric bypass and duodenal switch (also referred to as biliopancreatic diversion with duodenal switch), are offered at Mayo Clinic.
- Before meeting with a surgeon, patients seeking bariatric surgery at Mayo Clinic consult with an endocrinologist specializing in nutrition, a psychologist specializing in behavior modification and a registered dietitian, along with completing a behavior modification program.

and life-threatening medical problems, as well as substantially improving quality of life. Not surprisingly, the number of bariatric procedures performed yearly has dramatically increased over the past decade. As of 2011, approximately 225,000 bariatric operations are performed



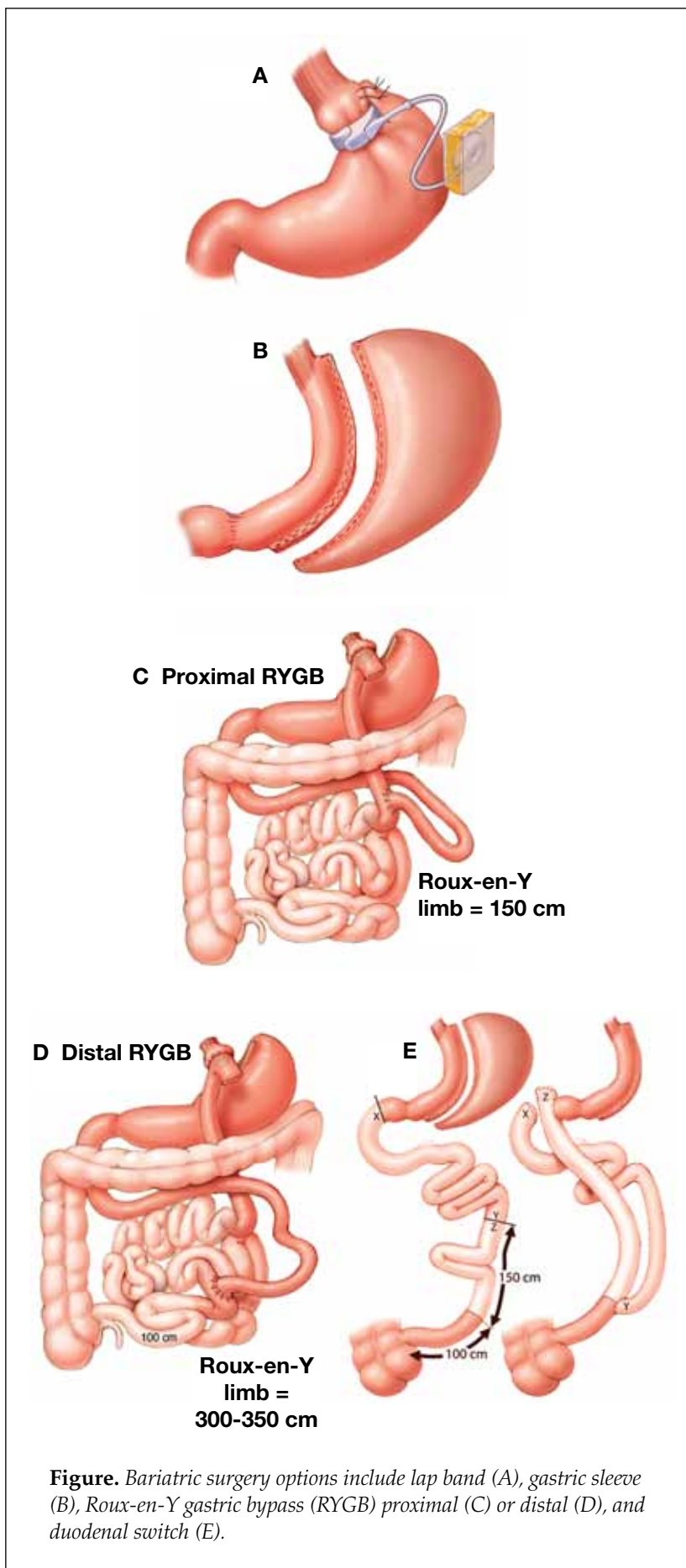
annually in the United States, a nearly 500 percent increase since 2000.

Several operative procedures (Figure), including sleeve gastrectomy, Roux-en-Y gastric bypass and duodenal switch (also referred to as biliopancreatic diversion with duodenal switch), are offered at Mayo Clinic, with the Roux-en-Y gastric bypass being the most common (approximately 74 percent of all cases). Given its lackluster long-term performance, the laparoscopic gastric band procedure is no longer being offered at Mayo Clinic. A different type of restrictive procedure, the sleeve gastrectomy (Figure), has taken its place. Although long-term outcome data for the sleeve gastrectomy are lacking, early results show considerable promise in terms of weight loss and improvement or remission of weight-related comorbidities.

Despite the overwhelming benefits to patients, bariatric surgery is not without complications. As such, presurgical patient selection and postsurgical follow-up are critically important. To provide optimum patient care, Mayo staff has implemented an integrated, multi-disciplinary approach to each patient seeking bariatric surgery. On referral, the patient meets with an endocrinologist specializing in nutrition, a psychologist specializing in behavior modification and a registered dietitian. A patient-specific, comprehensive medical weight management plan, centered on cognitive behavioral therapy, is then developed. When the behavior modification program is successfully completed, which on average takes three months, the patient is scheduled to meet with a surgeon to discuss which surgery may be best for him or her.

Mayo Clinic's multidisciplinary approach continues after surgery, with shared medical appointments that occur several times in the year following surgery and annually thereafter. This small group-based model allows for peer support among patients while controlling health care costs and limiting educational redundancy. Patients continue to be engaged as they incorporate lifestyle changes, with the hope of achieving greater weight loss that is sustained.

Despite these successes, continued efforts and research are needed to combat the obesity epidemic. An area of active investigation is the unfortunate phenomenon of weight regain after bariatric surgery. Mayo researchers aim to identify the factors contributing to weight regain and the potential interventions to prevent and manage it. Staff members are also exploring novel surgical treatment methods, including endoscopic procedures, that are targeted at weight maintenance after surgery.



**Figure.** Bariatric surgery options include lap band (A), gastric sleeve (B), Roux-en-Y gastric bypass (RYGB) proximal (C) or distal (D), and duodenal switch (E).

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Mayo Clinic welcomes inquiries and referrals, and a request to a specific physician is not required to refer a patient.

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## Resources

[MayoClinic.org/medicalprofs](http://MayoClinic.org/medicalprofs)

Clinical trials, CME, Grand Rounds, scientific videos and online referrals

## Education Opportunities

### Internal Medicine Review for Nurse Practitioners, Physician Assistants and Primary Care Providers

Sept. 18-20, 2013, Rochester, Minn.

This annual interdisciplinary course offers participants an overview of current topics in internal medicine, including interactive case studies using an automated audience response system. Interdisciplinary speakers present diverse clinical topics chosen for applicability to NP/PA and primary care physician practice settings. As care of complex patients transitions to the outpatient arena, current guideline-based medicine typically in the hospital setting continues to be important as patients are managed outside the hospital setting. For more information or to register, please call 800-323-2688 (toll-free) or email [cme@mayo.edu](mailto:cme@mayo.edu).

### Individualizing Medicine 2013: From Promise to Practice

Sept. 29-Oct. 2, 2013, Rochester, Minn.

This is the second annual conference sponsored by the Center for Individualized Medicine. As new discoveries in individualized medicine make their way into the clinic, they bring with them a new set of challenges. This conference aims to address practical issues of integrating pharmacogenomics, microbiomics, epigenomics and genomic medicine into the clinical practice. Topics for the conference include the integration of drug-gene pair alerts into the EMR; understanding which patients may benefit from whole genome and exome sequencing, interpretation and its relevance to prognosis and diagnosis; sharing complicated genomic information with patients; and discussion of regulatory, legal, and bioethical issues. For more information or to register, please call 507-293-0408 or email [imconference@mayo.edu](mailto:imconference@mayo.edu).

### 16th Annual Mayo Clinic Internal Medicine Update: Sedona 2013

Oct. 10-13, 2013, Sedona, Ariz.

This four-day course offers primary care physicians, nurse practitioners and physician assistants a practical update on a variety of subspecialty topics, including allergy, cardiovascular diseases, dermatology, endocrinology, gastroenterology, hematology, infectious diseases, integrative medicine, neurology, psychiatry, pulmonary, renal disease, rheumatology and others applicable to today's practice and patients. It is also offered Oct. 24-27, 2013. For more information or to register, please call 480-301-4580 or email [mca.cme@mayo.edu](mailto:mca.cme@mayo.edu).

### Mayo Clinic Hospital Medicine: Managing Complex Patients

Nov. 6-9, 2013, Tucson, Ariz.

The course is designed to provide a review of the most recent medical updates relevant to the care of hospitalized patients. Using an interactive, case-based format, the key highlights from all major areas of internal medicine and its specialties will be presented. An expert panel of distinguished Mayo Clinic academic physicians will present didactic lectures and address questions from the audience. For more information or to register, please call 480-301-4580 or email [mca.cme@mayo.edu](mailto:mca.cme@mayo.edu).

## Physician Update

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