Clinical Innovations and Outcomes
Cardiovascular and Thoracic Services

Northwell Health™
Northwell Health: New York’s Destination for Quality, Comprehensive Care

In 2016, we continue our journey with a new name: Northwell Health.

This new identity reflects our shared vision for the future, as we work together to discover extraordinary new ways to keep people healthy.

In the nearly two decades since the North Shore-LIJ Health System was formed, we have emerged as a national leader in patient care, scientific discovery, medical education and community involvement. Our commitment to guiding patients along a path of continued health and wellness is stronger than ever.

Northwell Health is the 14th largest health care system in the United States and the largest in New York State, looking after eight million people in the New York City metropolitan area. We care for our communities with a network of 21 hospitals, 6,600 hospital and long-term care beds, 450 ambulatory and physician practices and a staff of more than 15,000 highly skilled physicians and nurses with a range of specialties. The 61,000 dedicated professionals of Northwell Health are working together not only to meet your unique needs but to consistently exceed your expectations.

Here at Northwell Health, we help everyone equally and with dignity. Our staff comes from all over the world, allowing us to provide access to the very best care with language and culture in mind. By respecting and cherishing each individual’s identity, our
“Patients come first” isn’t a slogan here; it’s a promise and everyday practice.

provider-patient connection grows stronger and we can overcome barriers together. "Patients come first" isn’t a slogan here; it's a promise and everyday practice. We've received national recognition for our focus on patient safety and outcomes, but the greatest honor is helping our communities stay healthy with the highest quality care. Our achievements would not be possible without the future-focused work of The Feinstein Institute for Medical Research and the Hofstra Northwell School of Medicine. Both institutions are transforming medical education and biomedical research. At the Feinstein Institute, scientists and researchers are engaging in awe-inspiring studies — like investigating the frontier of bioelectric medicine or exploring the use of 3D printers for prosthetics. Our groundbreaking clinical trials test the next generation of promising therapies for conditions from Alzheimer’s to heart disease. Similarly, the Hofstra Northwell School of Medicine offers a refreshing take on medical education with a patient-centered focus. Students begin interacting with patients within the first semester, and become EMTs within the first nine weeks. This forward-looking approach creates the next generation of physicians and scientists — a diverse and driven community of students, residents and fellows who connect with patients from all corners of the globe.

We are many things, but every day we are one thing: dedicated to the community. We are Northwell Health — more than a health system.
Dear Colleagues,

Excellence is a word many organizations use, but how many actually achieve it every day?

At Northwell Health, we have the numbers to prove our commitment to excellence. Across our growing health system, excellence is a principle that pervades every aspect of care, whether it’s a trip to the emergency room, a routine checkup at the doctor’s office or a home visit with one of our dedicated nurses.

Twenty-first-century medicine is a dynamic and symbiotic relationship comprising research, care and education, each area informing the other. Ongoing collaboration with the Feinstein Institute for Medical Research allows us to offer innovative therapies and breakthrough technologies to our patients. Investing in educating the next generation of healers through the Hofstra Northwell School of Medicine also advances care, allowing us to better meet the unique health needs of our population.

As more patients turn to Northwell Health for cardiovascular and thoracic care, our specialists have refined and expanded treatment options to comprehensively address heart disease, including minimally invasive procedures, angioplasty and stenting, coronary artery bypass grafting, mitral valve repair and replacement, transcatheter aortic valve replacement and imaging modalities to identify peripheral vascular disease. Our cardiac program’s exemplary performance earned it the distinction of being selected to participate in a national clinical alliance with the prestigious Cleveland Clinic.

We also value our patients’ relationships with the medical professionals who refer them to our hospitals, and we consider them valuable members of the care team. We pride ourselves on keeping the lines of communication open for the patient’s best outcome.

Excellence isn’t just a word or a goal; it is daily practice here, executed routinely at every level.

This approach translates into truly high-quality care with superior outcomes in patient safety and restored health. However, despite our continued success, we approach excellence with humility, knowing that every task every day requires our best. Our patients deserve nothing less.
Table of Contents

Overview: Comprehensive Care Close to Home .......................................................... 7
Valvular Disease ......................................................................................................... 11
Structural Heart Disease ......................................................................................... 16
Diseases of the Aorta .............................................................................................. 20
Ischemic Heart Disease ............................................................................................ 22
Congestive Heart Failure ......................................................................................... 28
Peripheral Vascular Disease ................................................................................... 30
Heart Rhythm Disorders ......................................................................................... 32
Thoracic Surgery ..................................................................................................... 34
Our Commitment to Research ................................................................................. 40
A Focus on Education .............................................................................................. 46

Unless otherwise noted, cardiac surgery data includes North Shore University, Southside, Lenox Hill and Staten Island University Hospitals and LIJ Medical Center. Cardiology data includes LIJ Medical Center and Staten Island University, Huntington, North Shore University, Lenox Hill and Southside Hospitals.
Northwell Health specializes in managing a full spectrum of cardiovascular and thoracic conditions.
Comprehensive Care Close to Home

Cardiovascular disease remains the leading cause of mortality and morbidity in the United States. A nationwide obesity epidemic, coupled with an aging population, makes effective and efficient treatment of cardiovascular conditions all the more urgent.

Northwell Health provides patient-centered, accessible care throughout Long Island and the New York metropolitan area. Our treatments are based on a foundation of clinical research and feature the latest technologies. Northwell Health specializes in managing a full spectrum of cardiovascular and thoracic conditions, including:

- Aortic disease (including stenosis, dissection and aneurysm treatment)
- Cardiac rhythm disorders
- Structural and congenital heart disease
- Coronary artery disease
- Heart failure
- Peripheral vascular disease
- Lung cancer and other thoracic conditions
- Valvular heart disease

Our world-class, multidisciplinary team exemplify the very best in 21st century cardiac care that ranges from outpatient services to highly complex surgical procedures. Across our growing health system, our cardiologists and cardiothoracic surgeons and our dedicated clinical team collaborate with specialists in radiology, anesthesiology, rehabilitation and homecare to provide a full range of services. Moreover, the outcomes shown on these pages demonstrate our diligent adherence to best-practice medicine and evidence-based protocols.
When Time Is of the Essence

As part of one of the largest health systems in the United States, our cardiovascular and thoracic services department partners with Northwell Health’s Center for Emergency Medical Services (CEMS) to ensure that patients receive prompt access to treatment when they most need it. This impressive support service is the nervous system of Northwell Health, with a 24-hour command center that dispatches a network of ambulances from Manhattan to Montauk. CEMS can also call on SkyHealth, a helicopter service in partnership with Yale-New Haven Health that flies patients over traffic at 135 miles per hour. The sooner our cardiovascular team can provide treatment, the better the outcomes.

Distribution of Nonsurgical Cardiac Procedures - 2014

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Catheterization</td>
<td>18,125</td>
</tr>
<tr>
<td>Percutaneous Coronary Intervention (PCI)</td>
<td>7,892</td>
</tr>
<tr>
<td>Peripheral Intervention</td>
<td>1,338</td>
</tr>
<tr>
<td>Electrophysiology</td>
<td>5,466</td>
</tr>
<tr>
<td>Echocardiography</td>
<td>62,096</td>
</tr>
<tr>
<td>Stress Test (regular/nuclear)</td>
<td>18,038</td>
</tr>
<tr>
<td>Computed Tomography (CT)</td>
<td>2,806</td>
</tr>
</tbody>
</table>

Northwell Health surgeons performed 3,666 cardiac and major thoracic surgical procedures in 2014. Includes all Northwell Health hospitals.

The data on the following pages shows the strength of our programs not only in volume, but in patient safety and successful outcomes.

Distribution of Surgery Procedures - 2014

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Surgery</td>
<td>2,231</td>
</tr>
<tr>
<td>Isolated Coronary Artery Bypass Graft (CABG)</td>
<td>1,042</td>
</tr>
<tr>
<td>Valve Surgery</td>
<td>1,061</td>
</tr>
<tr>
<td>Transcatheter Aortic Valve Replacement (TAVR)</td>
<td>236</td>
</tr>
<tr>
<td>Major Thoracic Surgery</td>
<td>1,435</td>
</tr>
</tbody>
</table>

Following Your Heart

Receiving the best surgical and interventional care can be just the beginning of a patient’s treatment journey. Many patients who undergo cardiac surgery are readmitted to the hospital due to poor follow-up care or failure to adhere to discharge instructions. Follow Your Heart™ is Northwell Health’s program to help reduce preventable readmissions by providing patients with a continuum of care. Through this program, patients receive multiple follow-up visits at home from the same health care providers who treated them in the hospital. This is just one example of the many ways that our department cares for the whole patient, from diagnosis to discharge and follow up. This program is currently available at North Shore University, Southside and Staten Island University Hospitals as well as LIJ Medical Center.

Cardiac surgeons and interventional cardiologists work hand in hand to determine the best treatment for each patient’s unique case, with care often provided all at one location. Quite simply, patient satisfaction can help improve outcomes. The data backs this up; our cardiovascular surgery and interventional cardiology programs have been consistently ranked among the best in New York State by the NYS Department of Health, and the data on the following pages shows the strength of our programs not only in volume, but in patient safety and successful outcomes.

Our focus on the patient is never lost even as our geographic reach has increased. We have built a team of some of the most talented doctors, nurses and support staff, and these specialty-trained cardiovascular and thoracic professionals rely on a consistent set of practices and protocols across all sites to ensure a consistent patient experience and a focus on outcomes. Our reputation is what it is because of our tireless work ethic; we don’t turn anyone away regardless of the complexity or rarity of their conditions.

Patients at the Center of Care

What differentiates our program at Northwell Health is our patient-centered approach to addressing heart disease.
Research and Technology

To support this clinical expertise, Northwell Health invests in technology that can help improve patient care. From hybrid operating rooms equipped with the latest imaging equipment to the advanced robotic systems that permit our thoracic surgeons to perform remarkable procedures inside small incisions, our experts have access to the tools and techniques that provide the best care possible.

In addition, Northwell Health hospitals are frequently participants in significant clinical trials for the devices that will help define the future of cardiac care, and we are nationally recognized for our ability to recruit large numbers of patients for trial enrollment. Although research takes place across Northwell Health facilities, the organization operates under a single institutional review board (IRB). We have been instrumental in the development of nearly all commercially available transaortic valve replacement devices.

Some of our latest initiatives include a clinical trial of the COBRA PzF™ stent for patients with symptomatic ischemic heart disease and the Lotus™ Valve System for subjects with severe native aortic stenosis. Our researchers are also studying new devices for pacing and defibrillation in patients. (For more, see “Our Commitment to Research” on page 40.)

Quality and Outcomes

Our hospitals have received prestigious rankings by the NYS Department of Health, highlighting the fact that Northwell Health provides some of the best outcomes statewide for percutaneous coronary intervention (PCI) and cardiac surgery. Adding to our credentials as a leading cardiac care provider, we fulfilled their criteria for clinical excellence. This achievement is a reflection of our strong performance across the board. Cleveland Clinic evaluated our operating rooms, intensive care units, work flows, policies and procedures, mortality rates, imaging capabilities and other services, and we fulfilled their criteria for clinical excellence. The honor means that cardiac patients in our region will gain access to new and enhanced treatment options, as well as clinical trials and innovative technologies in cardiology and cardiac surgery. With this alliance Northwell Health is now a member of Cleveland Clinic’s Cardiovascular Specialty Network.
Valvular Disease

There are a number of conditions – congenital or acquired – that can cause the heart’s valves to function improperly.

At Northwell Health, we offer a full range of treatments to address valve disorders of any severity, including the latest minimally invasive options for replacement. Our team of internationally recognized cardiac surgeons and interventional cardiologists work closely together to ensure that care is seamless and coordinated.

Surgical Valve Repair and Replacement

Northwell Health specializes in complex surgical repair of the mitral and aortic valves and approaches each case individually. Our well-established program applies significant surgical experience to repairing valves, implanting bioprosthetic replacements and performing complex multivalve surgeries. The majority of valve surgeries at Northwell Health are complex combined and multivalve procedures.

In 2014, Northwell Health surgeons performed 1,061 valve surgery procedures.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

The mortality rates for isolated procedures were lower at Northwell Health than the rates expected by the Society of Thoracic Surgeons. Isolated procedures are those performed without any other surgical procedure.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

The mortality rates for isolated procedures were lower at Northwell Health than the rates expected by the Society of Thoracic Surgeons. Isolated procedures are those performed without any other surgical procedure.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

There are a number of conditions – congenital or acquired – that can cause the heart’s valves to function improperly.

At Northwell Health, we offer a full range of treatments to address valve disorders of any severity, including the latest minimally invasive options for replacement. Our team of internationally recognized cardiac surgeons and interventional cardiologists work closely together to ensure that care is seamless and coordinated.

Surgical Valve Repair and Replacement

Northwell Health specializes in complex surgical repair of the mitral and aortic valves and approaches each case individually. Our well-established program applies significant surgical experience to repairing valves, implanting bioprosthetic replacements and performing complex multivalve surgeries. The majority of valve surgeries at Northwell Health are complex combined and multivalve procedures.

In 2014, Northwell Health surgeons performed 1,061 valve surgery procedures.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

The mortality rates for isolated procedures were lower at Northwell Health than the rates expected by the Society of Thoracic Surgeons. Isolated procedures are those performed without any other surgical procedure.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
Our consistent approach yields excellent results across the five sites where these surgeries are performed. Despite a challenging caseload, the data on these pages demonstrates not only a considerable volume of experience but also outcomes that compare favorably to outcomes across the country reported to the Society of Thoracic Surgeons (STS).

Reoperations can be especially challenging due to the scar tissue from the initial operation. Our outcomes for these reoperations are below the expected 30-day mortality rate.

**Advanced Treatment Options**

Although not indicated for every case, minimally invasive approaches may be employed when appropriate. Northwell Health was among the first health systems on Long Island to employ the da Vinci™ robotic system to perform minimally invasive cardiac procedures including mitral valve repair.

Northwell Health surgeons performed 231 procedures that included mitral valve surgery in 2014.

**Northwell Health**

**Mitral Valve Surgery Volume (N=231)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Northwell Health</th>
<th>STS Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>150</td>
<td>120</td>
</tr>
</tbody>
</table>

**Northwell Health**

**Isolated Mitral Valve Surgery 30-Day Mortality**

<table>
<thead>
<tr>
<th>Year</th>
<th>Northwell Health</th>
<th>STS Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>15%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Northwell Health**

**Isolated Aortic Valve Replacement (AVR) 30-Day Mortality**

<table>
<thead>
<tr>
<th>Year</th>
<th>Northwell Health</th>
<th>STS Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

In 2014, the mortality rates for patients who had isolated mitral valve surgery were lower at Northwell Health than the expected rates for both repair and replacement procedures.

**Source:** Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
STS Overall ★★★ Quality Rating*

Two of our hospitals are among the 7.89 percent of hospitals that received an overall three-star rating — the highest rating given — from the Society of Thoracic Surgeons (STS) for isolated aortic valve replacement (AVR) surgery.

*Based on data comparisons from January 2014 to December 2014

Northwell Health
Valve Surgery Volume and Incidence of Reoperation
2014

Valve surgery reoperations are associated with a somewhat increased risk of death due to patients’ decreased overall health over time. Despite the increased risk, Northwell Health had lower than expected 30-day mortality rates in 2014 when compared to cases with associated risk algorithm to the observed rate.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

Northwell Health
Valve Surgery Reoperation
30-Day Mortality
2014

The majority of valve procedures performed at Northwell Health in 2014 were combined procedures. Reoperations made up 16.7% of all valve procedures.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

Northwell Health
Distribution of Isolated and Combined Valve Operations
2014 (N=1,061)

Northwell Health surgeons performed 1,061 valve procedures in 2014. The majority were first operations.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
Northwell Health’s interventional catheterization labs also manage stenotic cardiac valves using minimally invasive procedures.

Valvuloplasty, an approach similar to angioplasty, uses a balloon to open a stenotic cardiac valve and may be a viable alternative to surgery. Inserting the balloon stretches the valve or breaks up scar tissue to restore normal blood flow.

Northwell Health was also one of the first institutions to offer transcatheter aortic valve replacement (TAVR), placing a new valve via catheter, and has also adopted minimally invasive techniques for mitral valve repair. (See Transcatheter Aortic Valve Replacement (TAVR), Page 17.)

Northwell Health is a leader in the percutaneous valve repair and replacement, and trains surgeons internationally on this technology. Northwell Health offers all commercially available valve replacement options and participates in clinical trials testing the devices of the future.

The 30-day mortality rates at Northwell Health for combined procedures were lower than or equal to the rates expected by the Society of Thoracic Surgeons. Combined procedures are those performed with another surgical treatment and are generally more complex than isolated procedures.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

The complication rates associated with isolated aortic valve replacement were lower than expected for all complications.  
Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
Northwell Health specializes in treatment of patients with endocarditis. Patients benefit from a multidisciplinary approach that includes specialists from the Departments of Infectious Diseases and Neurointerventional Radiology.

Bacterial (infective) endocarditis is a life-threatening infection of the heart’s valves or the heart’s inner lining (endocardium). The condition causes growths on or holes in the valves or scarring of the valve tissue, most often resulting in a leaky heart valve. Northwell Health surgeons treat patients with active infective endocarditis, including those with advanced disease and prosthetic valve endocarditis.

In 2014, Northwell Health surgeons performed 49 valve procedures to treat patients with infective endocarditis.

Despite the increased risk, Northwell Health had lower than expected 30-day mortality rates in 2014 when compared to cases with an associated risk algorithm to the observed rate.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
Structural Heart Disease

Treatment of structural heart disease is a growing specialty with a focus on minimally invasive approaches. Areas of concentration include transcatheter aortic valve replacement, treatment of mitral valve disease, closure of congenital defects including atrial septal defect and patent foramen ovale and left atrial appendage closure.

Our structural heart disease program’s imaging specialists, cardiac surgeons and interventionalists work together to diagnose patients and to determine whether they are candidates for one of these procedures, which are performed in state-of-the-art hybrid operating rooms at Lenox Hill, North Shore University and Southside Hospitals and LIJ Medical Center.

Device Implantation for Structural Heart Disease

Device implantation via catheter is a rapidly evolving area of interest for our interventional cardiologists, introducing new minimally invasive options for structural heart conditions, including valve stenosis and prolapse, that once required major surgery.

Northwell Health
Transcatheter Aortic Valve Replacement (TAVR) Volume and 30-Day Mortality by Approach (N=236) 2014

- Northwell Health
- Expected

The TAVR procedure can be performed via several approaches. In 2014, Northwell Health doctors used the transfemoral approach in 164 procedures (30-day mortality, 4.3%). A nontransfemoral approach was used in 72 procedures (30-day mortality, 5.6%).

Northwell Health was an early leader in transcatheter aortic valve replacement (TAVR) procedures, and we also have wide experience correcting congenital and structural heart defects such as patent foramen ovale (PFO) and atrial septal defect (ASD) using the latest transcatheter closure devices.

**Transcatheter Aortic Valve Replacement (TAVR)**

Until recently, the only option to replace a stenosed aortic valve was complex surgery. Despite excellent outcomes in the hands of experienced surgeons, there were some patients who were not candidates for open surgical replacement. TAVR devices came to the United States for clinical trials in 2010, bringing new treatment options for older, at-risk patients.

During the TAVR procedure, the replacement valve is delivered via stent, avoiding the need for sternotomy. After a successful TAVR procedure, patients are typically able to walk within 48 hours and return to their homes in three to five days.

Northwell Health is among the nation’s leading hospitals in this procedure, which is currently approved for use in certain patients. Further research is being conducted to assess use in other patient populations.

**Source:** Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

Northwell Health is an early leader in transcatheter aortic valve replacement (TAVR) procedures, and we also have wide experience correcting congenital and structural heart defects such as patent foramen ovale (PFO) and atrial septal defect (ASD) using the latest transcatheter closure devices.

**Transcatheter Aortic Valve Replacement (TAVR)**

Until recently, the only option to replace a stenosed aortic valve was complex surgery. Despite excellent outcomes in the hands of experienced surgeons, there were some patients who were not candidates for open surgical replacement. TAVR devices came to the United States for clinical trials in 2010, bringing new treatment options for older, at-risk patients.

During the TAVR procedure, the replacement valve is delivered via stent, avoiding the need for sternotomy. After a successful TAVR procedure, patients are typically able to walk within 48 hours and return to their homes in three to five days.

Our cardiac surgery nurse practitioners, physician assistants and valve coordinators, who ensure constant communication between the physicians and patients, are also an important part of our treatment team.
Referring physicians are also kept abreast of treatment decisions and are often invited to watch procedures, providing an added layer of comfort for our patients.

Northwell Health has been instrumental in the development of nearly all commercially available TAVR devices. LIJ Medical Center was the first on Long Island to implant the Edwards SAPIEN Valve®, and Lenox Hill and North Shore University Hospitals were among the initial group of 40 hospitals to test the Medtronic CoreValve®. A variety of other valves are currently being studied in clinical trials at Northwell Health (see “Our Commitment to Research,” page 40), giving patients a full array of treatment options.

Because we have one of the highest TAVR patient volumes in the United States, our physicians are often asked to teach specialists at other medical institutions best practices for implanting these devices. Northwell Health’s TAVR program has grown steadily since its establishment, and our outcomes, including 30-day mortality, compare favorably with outcomes at other hospitals that perform this procedure. We remain on the cutting edge, participating in trials testing the newest devices that will benefit patients in the future.

Northwell Health
Transcatheter Aortic Valve Replacement 30-Day Mortality
2011-2014

A total of 236 patients had transcatheter aortic valve replacement (TAVR) procedures at Northwell Health in 2014. The 30-day mortality rate was 4.7%.

Congenital Heart Disease

Congenital heart disease impacts an estimated one million people in America. Each year, approximately one in every 120 babies born in the U.S. has a congenital heart defect. In some cases, the disease is life-threatening at birth. However, many people with a congenital heart condition do not know about it for years. Experts at Northwell Health have extensive experience in the diagnosis and treatment of patients with all forms of congenital heart disease.

Mitral Valve Procedures

The most common heart valve insufficiency is mitral valve prolapse, which can result in mitral regurgitation and for some patients, heart failure. Northwell Health offers the MitraClip® Delivery System, a new percutaneous technology that delivers a clip to partially close a mitral valve, reducing or eliminating regurgitation and the risk for heart failure. To date, the clip has been associated with improved left ventricular remodeling and a significant reduction in hospitalizations for heart failure.

Northwell Health participated in research that helped bring the MitraClip device to market and is now collecting follow-up data on patients who have undergone the procedure.

Protecting AFib Patients from Stroke

Atrial fibrillation (AFib), can introduce risk for ischemic stroke. Most patients with AFib take warfarin to prevent this complication, but for patients who cannot tolerate anticoagulants, Boston Scientific’s WATCHMAN™ is a percutaneously delivered occluder that is permanently implanted in the left atrial appendage (LAA), a common source of thrombosis that can break free and cause ischemic stroke. Northwell Health cardiologists were the first on Long Island to implant this device.

Percutaneous Coronary Interventions for Congenital Heart Disease

A total of 52 patients had percutaneous closure procedures with excellent outcomes.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percutaneous ASD Closures</td>
<td>44</td>
</tr>
<tr>
<td>Percutaneous PFO Closures</td>
<td>8</td>
</tr>
<tr>
<td>Percutaneous VSD Closures</td>
<td>2</td>
</tr>
</tbody>
</table>

ASD: atrial septal defect; PFO: patent foramen ovale; VSD: ventricular septal defect

Congenital Heart Disease

Percutaneous  ASD Closures

Percutaneous PFO Closures

Percutaneous VSD Closures

A total of 52 patients had percutaneous closure procedures with excellent outcomes.
Diseases of the Aorta

Diseases of the aorta, including aneurysms, dilatations and dissections, are being recognized and diagnosed with greater frequency. Northwell Health has become a regional leader in the treatment of aortic disease, and its reputation for high-quality care has led to a steady increase in volume. Specialists employ a variety of approaches involving valve repair or replacement that depend on the patient’s age, preexisting comorbidities and tolerance for surgery.

Monitoring Progress

While aortic disease sometimes presents as an acute event, conditions like aneurysms are often identified during a routine exam or after patient complaints of headache or blurred vision, via CT scan, echocardiography or MRI. But not every case of aortic disease requires immediate surgical intervention. Many aneurysms, for example, benefit from monitoring and medical treatment.

To monitor patients with aortic disease, Northwell Health was among the first organizations to institute an aortic registry. This registry includes all pertinent information so that specialists across the health system can monitor patients’ pathology, intervene earlier, follow up at appropriate intervals and potentially prevent emergency hospitalization or readmission.

When Minutes Matter

Aortic dissection is a life-threatening event that must be treated immediately. With the help of Northwell Health’s Center for Emergency Services (CEMS) and our cardiac surgeons, who are on call 24 hours a day, seven days a week, we can offer peace of mind.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014/New York State Department of Health
Surgical Interventions
When intervention becomes necessary, Northwell Health offers a full range of treatment options. Approaches include:

Open aortic repair: Experienced surgeons will determine the optimal surgical approach based on several factors: the location of the aneurysm, the type of aneurysm and the patient's tolerance for the procedure. In some cases, aneurysm repair may also impact the aortic valve, requiring a combined procedure.

Endovascular aneurysm repair (EVAR): Northwell Health was among the first institutions to adopt endovascular aneurysm repair, a procedure in which a catheter-deployed endograft is placed in the area of the diseased aorta. Although not indicated in every case, this approach is associated with lower operative mortality and a faster recovery time than traditional open surgery.

Our program handles a large number of cases and those cases are associated with excellent outcomes.
Ischemic Heart Disease

Northwell Health offers a comprehensive range of surgical and minimally invasive approaches to treat coronary artery disease, also known as ischemic heart disease. With ischemic heart disease, the goal is to restore circulation to the heart where a blockage occurs in a coronary artery, also called revascularization.

Our multidisciplinary approach ensures that each patient receives the most appropriate care for his or her condition, in one of our state-of-the-art facilities across the region. At Northwell Health, we focus on treating the whole patient, this means a focus not only on the procedure, but also on lifestyle changes, rehabilitation and follow-up care.

STS Overall ★★★ Quality Rating*

Two of our hospitals are among the 9.38 percent of hospitals that received an overall three-star rating — the highest rating given — from the Society of Thoracic Surgeons (STS) for isolated CABG surgery.

*Based on data comparisons from January 2014 to December 2014
Experience and Excellence

We are proud of our excellent outcomes for both surgical and interventional treatments for ischemic heart disease. Northwell Health applies best practices from each of our facilities to establish a consistent set of protocols with the goal of providing consistent, effective care.

As a result, several Northwell Health facilities have been recognized by the New York State Department of Health as having outstanding success rates for emergency and non-emergency angioplasty. Despite a challenging caseload, our outcomes compare favorably with the American College of Cardiology’s National Cardiovascular Data Registry (ACC-NCDR) registry hospitals.

For cardiac surgery, Northwell Health hospitals are among the 9.38% of hospitals that achieved an overall three-star rating — the highest rating given — from the Society of Thoracic Surgeons (STS) for CABG surgery.

Primary Isolated CABG: Age-Related Risk of 30-Day Mortality

The complexity of CABG procedures increases with age. The majority of patients who had primary isolated CABG surgery at Northwell Health in 2014 were 60 and older. Mortality rates were lower than expected for all age groups, except among patients younger than 50. Northwell Health continuously works to achieve the best possible outcome for every patient.

<table>
<thead>
<tr>
<th>Age</th>
<th>Observed Mortality (%)</th>
<th>Expected Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50 Years</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>50-59 Years</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>60-69 Years</td>
<td>1.4</td>
<td>1.9</td>
</tr>
<tr>
<td>70-79 Years</td>
<td>0.7</td>
<td>2.9</td>
</tr>
<tr>
<td>≥ 80 Years</td>
<td>1.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Total (N=1,015)</td>
<td>1.1</td>
<td>2.3</td>
</tr>
</tbody>
</table>

2014 National Quality Forum Measures:
Internal mammary artery (IMA) usage: 98.7%
Preoperative beta blocker: 97.6%
An Alliance for Better Outcomes

Another indicator of Northwell Health’s excellence in cardiac surgery — in 2014, the Cleveland Clinic Heart & Vascular Institute selected our organization to serve as its exclusive alliance member in the New York metropolitan area. Cleveland Clinic found that North Shore University Hospital met the strenuous criteria required to become a member of its alliance and cardiovascular specialty network.

Coronary Artery Bypass Surgery

Our established cardiac surgery programs across our service area perform a full range of cardiac surgery, including coronary artery bypass graft (CABG). Although catheter-based approaches have grown in popularity, CABG surgery is still widely indicated for complex cases including multivessel disease, cases with certain comorbidities or a blockage in the left main coronary artery.

Our CABG surgery results compare well with both New York State and STS databases, with lower than expected 30-day mortality for both primary procedures and reoperations. Our 2014 reoperation mortality was 0 percent. The majority of our primary CABG patients are older than 60, and we have lower than expected mortality for all age groups over 60, including an observed mortality rate of only 1.0 percent for patients 80 or older.

Northwell Health surgeons performed 1,042 isolated CABG procedures in 2014.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

The 30-day mortality rate for isolated CABG was 1.1%, which was lower than the expected rate of 2.4%.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014
Interventional Cardiology Procedures and Techniques

Northwell Health’s six state-of-the-art catheterization labs offer a full range of interventions including diagnostic catheterization, percutaneous coronary intervention (PCI), stent placement, valvuloplasty and orbital atherectomy.

Our specialists in the cardiac catheterization laboratories perform 12,000 to 15,000 diagnostic coronary procedures and more than 4,500 stent procedures annually. For the last decade, we have earned the prestigious NYS Department of Health double-star asterisk rating for catheterization procedure mortality outcomes that were significantly better than statewide averages.

Despite a patient population with complex backgrounds that include older age and higher rates of diabetes, prior CABG and multivessel disease than patients in the ACC-NCDR registry, the rates of major vascular complications and risk-adjusted bleeding events associated with PCI were lower than at ACC-NCDR Registry hospitals. In addition, the inpatient hospital mortality rate among patients who had PCI at Northwell Health facilities in 2014 was lower than the rate at comparable hospitals.

This is in part due to the expertise of the cardiac interventionalists as well as the consistent application of standardized protocols, including the use of adjunctive medications.

In high-risk patients, our specialists use a percutaneous ventricular assist device (pVAD), a mechanical pump that provides the heart with short-term support while it heals. Our interventional cardiologists have the most experience using pVAD on the East Coast.

---

Ischemic Heart Disease - Isolated CABG 2014

- Postoperative Stroke
- Ventilator Time > 24 Hours
- Reoperation
- Postoperative Renal Failure
- STS Expected

The observed rate of patients who had a postoperative stroke after isolated CABG was 0.4% at Northwell Health. This is lower than the expected rate of 1.4%.

A total of 7.6% of patients who had isolated CABG surgery at Northwell Health in 2014 spent more than 24 hours on a ventilator. This is lower than the expected rate of 13.4%.

The observed rate of reoperation after isolated CABG was 1.5% at Northwell Health. This is lower than the expected rate of 6.1%.

Postoperative renal failure occurred in 1.5% of patients who had isolated CABG surgery at Northwell Health in 2014. This was lower than the expected rate of 4.3%.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

---

Isolated CABG Procedures, 30-Day Mortality Primary and Reoperation (N=1,042) 2014

- Northwell Health
- Expected

Patients who have CABG reoperations have very complex medical histories, which creates a higher risk of death. The observed 30-day mortality rates at Northwell Health were lower than expected for both primary surgeries and reoperations.

Source: Society of Thoracic Surgeons (STS) National Adult Cardiac Surgery Database 2014

---

Interventional Cardiology Procedures and Techniques

Northwell Health’s six state-of-the-art catheterization labs offer a full range of interventions including diagnostic catheterization, percutaneous coronary intervention (PCI), stent placement, valvuloplasty and orbital atherectomy.

Our specialists in the cardiac catheterization laboratories perform 12,000 to 15,000 diagnostic coronary procedures and more than 4,500 stent procedures annually. For the last decade, we have earned the prestigious NYS Department of Health double-star asterisk rating for catheterization procedure mortality outcomes that were significantly better than statewide averages.

Despite a patient population with complex backgrounds that include older age and higher rates of diabetes, prior CABG and multivessel disease than patients in the ACC-NCDR registry, the rates of major vascular complications and risk-adjusted bleeding events associated with PCI were lower than at ACC-NCDR Registry hospitals. In addition, the inpatient hospital mortality rate among patients who had PCI at Northwell Health facilities in 2014 was lower than the rate at comparable hospitals.

This is in part due to the expertise of the cardiac interventionalists as well as the consistent application of standardized protocols, including the use of adjunctive medications.

In high-risk patients, our specialists use a percutaneous ventricular assist device (pVAD), a mechanical pump that provides the heart with short-term support while it heals. Our interventional cardiologists have the most experience using pVAD on the East Coast.
We also specialize in the radial artery (wrist) approach to PCI, which can decrease major bleeding complications and help patients recover more quickly. Patients are able to sit up, walk and eat immediately after the procedure.

At the Cutting Edge of Brachytherapy
Northwell Health was the first on Long Island and is one of the few on the East Coast to offer patients intravascular brachytherapy. This treatment applies radiation directly to the narrowed vessel and has been shown to inhibit restenosis following treatment. Studies have also shown intravascular brachytherapy to be a safe and effective treatment for post-drug-eluting stent restenosis. In fact, we have found brachytherapy to be a safer alternative to repeat stents with significantly lower rates of major adverse cardiovascular events. We have performed more than 350 brachytherapy procedures for patients experiencing restenosis after receiving a drug-eluting stent.

Innovations in Plaque Removal
Atherectomy is an innovative procedure used to remove tough, calcified or unstable plaque that uses small tools guided to the site to shave or ablate calcium deposits off the arterial wall. Our doctors use the latest approaches to atherectomy, including orbital, rotational and laser technology. Atherectomy has applications in ischemic heart disease, valve disease and peripheral vascular disease.

In 2014, the rate of major vascular complications and risk adjusted bleeding events compares favorably with patient outcomes in the ACC-NCDR database. The rates of stroke was slightly higher.

Source: ACC-NCDR Database.

Northwell Health
PCI Procedure Complications
2014

<table>
<thead>
<tr>
<th></th>
<th>Northwell Health</th>
<th>ACC-NCDR U.S. Registry Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPOSITE: DEATH, EMERGENCY CABG, STROKE OR REPEAT TARGET VESSEL REVASCULARIZATION</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>STROKE</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>RISK-ADJUSTED BLEEDING EVENT</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: ACC-NCDR Database.

Northwell Health
Risk Factors Among Patients Undergoing PCI Procedures
2014 (N= 7,892)

<table>
<thead>
<tr>
<th></th>
<th>Northwell Health</th>
<th>ACC-NCDR U.S. Registry Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE &gt; 75 YEARS</td>
<td>0%</td>
<td>12.5%</td>
</tr>
<tr>
<td>ACUTE CARE TRANSFER</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>PRIOR MI</td>
<td>25%</td>
<td>15%</td>
</tr>
<tr>
<td>PRIOR HEART FAILURE</td>
<td>12.5%</td>
<td>10%</td>
</tr>
<tr>
<td>DIABETES</td>
<td>40%</td>
<td>35%</td>
</tr>
<tr>
<td>PRIOR CABG</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>SEVERE LV DYSFUNCTION</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>MULTIVESSEL DISEASE</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Source: ACC-NCDR database.

Data Includes: LIJ Medical Center and Staten Island University, Huntington, North Shore University, Lenox Hill and Southside Hospitals.
When Time Is Muscle

When a patient has an acute ST segment elevation myocardial infarction (STEMI), every minute counts. Since 2006, the ACC and the American Heart Association (AHA) set a “door-to-balloon” guideline of less than 90 minutes, meaning revascularization within 90 minutes of arrival at the hospital. In 2013, that guideline was revised to 60 minutes, and we are well on our way to meeting that standard, with a median door-to-balloon time in 2014 of 61.5 minutes.

Northwell Health

Use of Adjunctive Medications Before and After PCI Procedures

2014 (N = 1,730)

<table>
<thead>
<tr>
<th>Medication</th>
<th>Northwell Health</th>
<th>ACC-NCDR U.S. Registry Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some ASPIRIN ON</td>
<td>100%</td>
<td>75%</td>
</tr>
<tr>
<td>Some ASPIRIN STATINS</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>Some THIENOPYRIDINES</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Before Procedure</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>At Discharge</td>
<td>0%</td>
<td>25%</td>
</tr>
</tbody>
</table>

One of the ACC-NCDR key performance measures is the use of appropriate adjunctive medications before and after PCI. Northwell Health’s administration rates exceed those of U.S. registry patients.

Source: ACC-NCDR Database.

Northwell Health

Door-to-Balloon Time (minutes)

2014 (N=381)

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Northwell Health</th>
<th>ACC-NCDR Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100%</td>
<td>75%</td>
</tr>
<tr>
<td>25</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>50</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>75</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>100</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Source: ACC-NCDR Database.

Northwell Health

Radial Artery Approach

2014 (N=7,921)

<table>
<thead>
<tr>
<th>Approach</th>
<th>Northwell Health</th>
<th>ACC-NCDR Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial</td>
<td>60%</td>
<td>45%</td>
</tr>
<tr>
<td>Femoral</td>
<td>45%</td>
<td>30%</td>
</tr>
<tr>
<td>Iliac/Anterior</td>
<td>30%</td>
<td>15%</td>
</tr>
<tr>
<td>0</td>
<td>15%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Source: ACC-NCDR Database.

When a total of 381 patients treated for myocardial infarction at Northwell Health EDs met the ACC-NCDR reporting criteria for a primary diagnosis of STEMI. Among these patients, median time to reperfusion was 61.50 minutes.
A Comprehensive Multidisciplinary Approach

In 2014, Northwell Health established an advanced cardiac therapy program to improve the management of patients with heart failure and reduce hospitalizations. The program has a structure similar to that of a transplant center, where a multidisciplinary team of cardiologists, cardiac surgeons, nurse practitioners, nurses, nutritionists, social workers, pharmacists and palliative care specialists collaborate to address individual needs of patients. We have a continued focus on the recruitment of prominent cardiologists and cardiac surgeons specializing in advanced cardiac care, who will further develop the program and standardize the care of our patients.

Staged Therapies

A combination of lifestyle changes, close monitoring, patient education and medical management can often help to improve symptoms and stop the progression of heart failure. Patients who remain symptomatic or whose disease continues to progress can be candidates for surgery. We currently offer ventricular assist devices (VADs) to support the function of the heart, either as a destination therapy or as a temporary treatment while awaiting transplant; as well as coronary revascularization, valve surgery, ventricular remodeling and surgery to correct abnormal heart rhythms.

Northwell Health began using the CardioMEMS™ heart failure system in 2014 to measure and monitor pulmonary artery pressure (PAP) and heart rate in select heart failure patients. The CardioMEMS device is implanted in the pulmonary artery via catheter.

At Northwell Health, heart failure patients work with a multidisciplinary care team to closely manage heart failure symptoms and reduce the need for hospitalization.
The device does not require batteries or wires; it is connected to a computer that provides data to the care team. The advantage is that clinical readings are provided in real time from nonclinical settings such as the patient’s home or an outpatient facility. This device has been proven to significantly reduce hospital admissions when used by physicians to manage heart failure.

Clinical Research for Advanced Cardiac Therapy

Northwell Health continues to be at the forefront of clinical research and is expanding treatment options for patients with heart failure to include clinical trials. Participation in these studies offers patients with advanced heart disease new therapy options.

The chart at right shows the results of a study comparing quality-of-life outcomes between patients who had a pulmonary artery pressure device (like CardioMEMS) and similar patients being followed in an ambulatory heart failure clinic.

Northwell Health began using the CardioMEMS™ heart failure system to measure and monitor pulmonary artery pressure and heart rate in select heart failure patients.

Pulmonary artery pressure (PAP) monitoring led to a dramatic improvement in quality of life parameters in this community-based sample. These findings suggest a patient-oriented benefit for monitoring patients with a PAP device.
Peripheral Vascular Disease

A Range of Approaches for Peripheral Vascular Disease

Peripheral vascular disease (PVD) is a common but serious chronic condition in which blood flow to the extremities is reduced due to arteriosclerosis. Some cases are asymptomatic, though many other patients present with leg pain or claudication. The goals of any treatment are restoring blood flow, preserving tissue, alleviating symptoms and preventing further cardiovascular complications.

First-line treatments often entail medication such as cilostazol (Pletal) to stop the progression of arteriosclerosis, alleviate leg pain, reduce leg stiffness, improve movement and reduce the risk of heart attack and stroke. When combined with lifestyle modifications, this approach can be effective.

When medication is not enough, a wide range of minimally invasive and open revascularization treatments are available. Some of these procedures can be performed in an ambulatory setting, allowing patients to receive care in a convenient office setting and return home in the same day. Over the last two years, the volume of our PVD cases has increased significantly thanks to more sophisticated diagnostics.

Angioplasty and iliac stenting are the gold standard in minimally invasive techniques, and are ideal for short lesions. In this technique, a stent is used to revascularize the vessel, restoring blood flow to the hips, legs and feet. Across Northwell Health’s hospitals and facilities, thousands of these procedures are successfully carried out each year. Another option is using atherectomy to cut and capture accumulated plaque.

In certain cases, such as those with longer lesions or more advanced disease, open vascular surgery may be a more viable option. These procedures include surgically bypassing the lesion or endarterectomy, a surgical removal of the plaque in the vessel.

Northwell Health
Iliac Stenting Volume
2013-2014

Northwell Health
Noninvasive Vascular Lab
Ultrasound Studies Volume
2013-2014

A total of 48 iliac stenting procedures were performed at Northwell Health in 2014. The use of stents to treat patients with iliac occlusive disease has increased in recent years. The treatment is associated with excellent outcomes (restoring blood flow and minimal complications).
Vascular Access Procedures

Another group of procedures commonly performed in Northwell Health’s cath labs involve vascular access to provide transport for hemodialysis, chemotherapy medications or drip delivery of antibiotics and other drugs. These advanced procedures include arteriovenous (AV) fistulas, AV grafts and venous catheters.

Although rarely as life-threatening as arterial conditions, there are a number of venous conditions that patients seek relief for in our facilities. These conditions include but are not limited to varicose and spider veins (treatments include laser, sclerotherapy, endovascular repair, ligation and radiofrequency ablation). Our cardiovascular and thoracic surgeons are also experienced in treating deep vein thrombosis (DVT), with medical therapy as well as the delivery of thrombolytic agents via catheter.

Northwell Health interventional cardiologists perform a variety of procedures to treat patients with peripheral artery conditions. They are skilled at angioplasty, stenting, thrombectomy and thrombolysis.

Tibial angioplasty intervention is the primary choice in the treatment of rest pain, ulcers and gangrene. In addition to tibial angioplasty, femoral-popliteal angioplasty is used in the treatment of patients with claudication. In 2014, Northwell Health performed 16 tibial, and 154 femoral-popliteal and 36 infra-popliteal angioplasty procedures.
Heart Rhythm Disorders

Although heart rhythm disorders may be the result of a structural or circulatory defect, they are typically related to an issue with the heart’s conduction. Northwell Health’s electrophysiologists study the electrical activity of the heart to determine how best to intervene and restore normal heart rhythm.

Northwell Health electrophysiologists use specialized approaches to diagnose and treat patients with a wide variety of arrhythmias. They are noted for their expertise in ablation procedures and management of patients with pacemakers and defibrillators.

Conditions treated include:

- Atrial fibrillation (AFib)
- Premature ventricular complex
- Supraventricular tachycardia (SVT)
- Wolff-Parkinson-White syndrome
- Ventricular tachycardia (VT)

The total number of procedures includes some that are not detailed in this graph. Other procedures include EP study, ICD testing, temporary pacemaker and loop recorder.

Source: Internal tracking database.
A Full Range of Treatment Options

Working in EP labs equipped with the latest diagnostic and treatment technologies, electrophysiologists are able to pinpoint the source of the patient’s arrhythmia and determine the best course of treatment. Most rhythm disorders are harmless and patients can be educated how to avoid or manage episodes; many other arrhythmias respond to medical management with beta blockers or calcium channel blockers. When intervention is required, we offer a full range of treatments.

EP mapping and ablation: Performed in the EP lab, this catheter-based procedure uses advanced imaging to map the electrical activity of the heart, identifying any discrepancies in the conduction system. When the abnormal rhythm is identified, the electrophysiologists can use radiofrequency or cryoablation to correct the defect.

Device implantation: There are a variety of devices available that can help correct abnormal heart rhythm, including implantable cardioverter defibrillators (ICDs) and pacemakers. New technology continues to advance the sophistication of these devices; the latest can monitor heart rate and help make real-time adjustments to correct a rate that is too fast or too slow. Other new models are MRI-safe, permitting patients to undergo this important imaging modality.

Device Implants


<table>
<thead>
<tr>
<th>2014 device implants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ICDs</td>
<td>1,338</td>
</tr>
<tr>
<td>Pacemakers</td>
<td>1,941</td>
</tr>
</tbody>
</table>

Northwell Health
Device Clinic Evaluation Volume
2011-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Device ICD/Pacemaker</th>
<th>Remote</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>225</td>
<td>75</td>
</tr>
<tr>
<td>2012</td>
<td>225</td>
<td>75</td>
</tr>
<tr>
<td>2013</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>2014</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

Source: Internal tracking database.
Data includes LIJ Medical Center, North Shore University, Lenox Hill, Huntington and Southside Hospitals.
Thoracic Surgery

Northwell Health’s skilled thoracic surgeons specialize in the treatment of most common forms of chest and lung diseases as well as surgeries for less common conditions, using a combination of traditional open surgical approaches and the latest in robotic video-assisted thoracic surgery (VATS).

Our physicians, nurse practitioners and administrative staff work together to provide continuing follow-up care for patients once treatment is complete. We also ensure that our physicians are available to address patient concerns 24 hours a day, seven days a week.

The thoracic surgeons at Northwell Health work hand-in-hand with cardiac care specialists, often collaborating on complex surgical cases. General thoracic surgery is a broad discipline encompassing treating diseases that affect the lungs, airways, diaphragm, vasculature (particularly the large vessels), esophagus and chest wall. The Northwell Health thoracic surgery team has earned a reputation as a leading, multidisciplinary group skilled at treating some of the most complex diseases, such as thoracic aortic aneurysm, mediastinal disease and progressive lung cancer.

Our steady growth in surgical volume over the past several years is a testament to the talent of our thoracic surgeons and the application of new technology to treat an ever-increasing range of conditions. Surgeries for conditions of the lungs and pleura comprise the majority of our procedures (81.9%) followed by conditions of the esophagus (7.8%), mediastinum and diaphragm (7.8%) and a full range of other procedures (2.5%).

Lung resections are one of the highest-volume procedures, and our high rate of minimally invasive procedures is associated with a shorter length of stay. Lobectomies represent the highest number of resections at our facilities, followed by wedge resections.

Northwell Health
Major Thoracic Surgery Volume
2011-2014

In 2014, Northwell Health surgeons performed 1,435 major thoracic surgical procedures.

Source: Departmental System Database 2014. Includes all hospitals performing thoracic surgery.
Lung Cancer
Northwell Health thoracic surgeons are often called upon as part of a multidisciplinary oncology team to treat patients with lung cancer. Although we choose the best approach for each patient’s unique circumstances, our rates of robotic surgery utilization are among the highest in the country, and we are able to apply these techniques for 75 percent of lung cancer cases, helping patients with more rapid recovery.

Notably, VATS lobectomy, with or without a robotic platform, offers patients fewer surgical complications compared to an open approach; it is the most common form of surgery used throughout the United States. VATS lobectomy is also better tolerated by the elderly and, overall, provides a short length of stay and a low mortality rate.

Lung Cancer Screening
Northwell Health is committed to early detection and elimination of lung cancer. Northwell Health offers free low-dose CT scan lung cancer screenings to smokers ages 55 to 80 who have a 30-pack-year smoking history, or those who have quit within the last 15 years. The early detection of cancer can help to improve survival and provides an opportunity for cure. We also actively promote smoking cessation to help prevent the disease.

Lung and Pleural Disease
Our surgeons also perform lung surgery to treat alveolitis, bronchiectasis, and bronchiolitis, if other therapies such as medications and/or lung physical therapy aren’t effective.

If placement of a chest tube between the ribs and into the air cavity does not effectively relieve pneumothorax, our surgeons may use VATS to repair the leak site with an endoscopic stapler. Our specialists may also use VATS to treat pleural effusion to drain and examine the chest cavity.
35% of major thoracic cases are done using a robotic approach.

**Esophageal Conditions**
Northwell Health performs surgery to treat a variety of esophageal conditions. These procedures include:
- **Modified Heller myotomy** to treat achalasia. The procedure reduces the risks of regurgitation and aspiration pneumonia.
- **Fundoplication** to treat Barrett’s esophagus and gastroesophageal reflux disease.
- **Minimally invasive esophagectomy**, which involves removing a portion of the esophagus and potentially some of the stomach. Surgeons then transfer the remaining section of the stomach, which acts as a new conduit for food.

**Airway Conditions**
Patients who are referred to Northwell Health with respiratory conditions including asthma, occupational asthma, bronchitis, tracheal stenosis, emphysema and chronic obstructive pulmonary disease (COPD) are offered a full range of non-surgical therapeutic treatments. These include smoking cessation, anti-inflammatory medications, regular oxygen supplementation and pulmonary rehabilitation.
Hiatal Hernia

Our surgeons also treat hiatal hernia that does not respond to medications prescribed by a gastroenterologist. A minimally invasive laparoscopic or robotic procedure may be used to place the protruding part of the stomach back into the abdomen. Sometimes, our surgeons access the hernia between the ribs, directly into the chest cavity, particularly in complicated cases or repeat operations.
Myasthenia Gravis

Surgery may offer a permanent cure or significant improvement in patients with myasthenia gravis. We offer minimally invasive approaches, including video thoracoscopic, trans-cervical, and robotic techniques for removing the thymus gland and any associated thymoma. Our surgical volume for myasthenia gravis is one of the highest in the five boroughs.

Hyperhidrosis

Hyperhidrosis, sometimes referred to as “sweaty palm syndrome,” is an embarrassing and disruptive condition marked by excessive perspiration. Surgeons can employ a minimally invasive surgical technique known as endoscopic thoracic sympathectomy (ETS) to treat this condition.

Northwell Health

Major Thoracic Surgeries
Lung Cancer Resections by Type
2014

Source: Society of Thoracic Surgeons (STS) National Thoracic Surgery Database 2014. Data does not include community hospitals or Staten Island University Hospital. Staten Island began STS participation in 2015.
Northwell Health offers a full range of thoracic surgeries for diseases of the lungs, pleura, esophagus and mediastinum and diaphragm. Pulmonary procedures were the most common.

Source: Society of Thoracic Surgeons (STS) National Thoracic Surgery Database 2014. Data does not include community hospitals or Staten Island University Hospital. Staten Island began STS participation in 2015. Includes cases that met STS criteria for major thoracic surgery.
Our Commitment to Research

**Research as a Foundation**
Research is a critical component of Northwell Health and provides the foundation for all of our patient care programs. With 20 research coordinators at six hospitals, we conduct research across Northwell Health, and collaborate with scientists at the Feinstein Institute for Medical Research on cardiovascular clinical trials.

**Professional and Industry Recognition**
Our investigators, many of whom have more than 20 years of research experience, are well respected within the academic community and are continually approached to participate in industry-sponsored, multicenter clinical trials, featuring the latest cutting-edge technologies for treating cardiovascular disease. We are also recognized for our ability to recruit large numbers of patients for trial enrollment.

Because of our experience, our researchers now serve as proctors at other academic institutions, providing their guidance and best practices for using many new devices.

With our new leadership role in the New York Metropolitan Chapter of the Association of Clinical Research Professionals, we expect new regional networking opportunities in the pharmaceutical, medical device and biotechnology industries to arise in the years to come.
On the Forefront of Structural Heart Disease

The Cardiovascular Institute is actively involved in numerous clinical trials, many of which are investigating new devices in interventional cardiology.

Northwell Health is currently involved in a prospective, international, multicenter, nonrandomized, single-arm clinical trial of a novel stent, the COBRA PzF™ (CeloNova) in patients with symptomatic ischemic heart disease. This stent uses a much thinner coating of polymers than found on currently available drug-eluting stents. Researchers want to know if this coating leads to faster and more natural healing of the artery and reduces the need for long-term dual antiplatelet therapy.

We were among 40 sites in the nation selected in 2010 to participate in Medtronic’s CoreValve® U.S. pivotal trial evaluating an investigational aortic valve replacement procedure in patients with severe aortic stenosis. In this ongoing study, participants benefit from four different valve sizes and three entry sites based on the anatomy and size of the patient’s arteries. This approach offers an alternative treatment option to replace a heart valve without open-heart surgery. We continue to enroll patients who have risks associated with undergoing surgery.

Additionally, we are comparing the safety and efficacy of a new device from Direct Flow Medical, Inc., the Direct Flow Medical® Transcatheter Aortic Valve System, with CoreValve in high- and extreme-risk subjects with severe symptomatic aortic stenosis. This study, the SALUS Trial, is currently recruiting patients.
Northwell Health is participating in the PARTNER II trial to determine the safety and effectiveness of the Edwards SAPIEN XT™ and the Edwards SAPIEN 3™ transcatheter heart valve and delivery systems (Edwards Lifesciences) in patients with symptomatic, calcific, severe aortic stenosis. Notably, in 2011, LIJ Medical Center was the first facility in Queens and Long Island to implant the FDA-approved SAPIEN® Transcatheter Aortic Valve. This FDA-approved device is now also available at North Shore University Hospital, Southside Hospital and Lenox Hill Hospital.

We are also enrolling patients into the REPRISE III study. The study objective is to evaluate the safety and effectiveness of the Lotus™ Valve System (Boston Scientific) for TAVR in symptomatic patients with calcific, severe native aortic stenosis. These individuals considered at extreme or high risk for surgical valve replacement. The Lotus Valve System is the first TAVR device that is both fully repositionable and retrievable prior to release.
New Approaches to Pacing and Defibrillation

We are also participating in the NAVIGATE X4 clinical study, which is evaluating the safety, performance and efficacy of the next-generation ACUITY™ X4 left ventricular pacing leads and Reliance 4-Front™ ICD leads (Boston Scientific). Study outcomes will help to satisfy Food and Drug Administration requirements for premarket submission.

Our scientists are also studying whether a noninvasive wearable cardioverter defibrillator (WCD) will reduce sudden death and death due to ventricular arrhythmia in the first 90 days following a myocardial infarction. They are studying this technology in individuals with left ventricular dysfunction with weakened heart muscle.
<table>
<thead>
<tr>
<th>Research Studies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CARDIOTHORACIC SURGERY</strong></td>
<td></td>
</tr>
<tr>
<td>LEVO-CTS</td>
<td>To evaluate the efficacy of levosimendan compared with placebo in reducing the 30-day composite event rate of all-cause death, perioperative MI, need for dialysis or use of mechanical assist (IABP or LVAD) in subjects with reduced ejection fraction undergoing cardiac surgery on CPB.</td>
</tr>
<tr>
<td><strong>STRUCTURAL HEART</strong></td>
<td></td>
</tr>
<tr>
<td>REPRISE III</td>
<td>To evaluate the safety and effectiveness of the Lotus™ Valve System for transcatheter aortic valve replacement (TAVR) in symptomatic subjects with calcific, severe native aortic stenosis who are considered at extreme or high risk for surgical valve replacement.</td>
</tr>
<tr>
<td>Medtronic CoreValve® Expanded Use Study</td>
<td>To characterize clinical outcomes through 5 years post-procedure of the Medtronic CoreValve® System (MCS) in the post-approval environment.</td>
</tr>
<tr>
<td>Partner II</td>
<td>To establish the safety and effectiveness of the Edwards SAPIEN Transcatheter Heart Valve device and delivery systems, which are intended for use in patients with symptomatic calcific, severe aortic stenosis. It is a randomized, multicenter trial with two population cohorts, the operable cohort designated as Cohort A and the inoperable cohort designated as Cohort B.</td>
</tr>
<tr>
<td>Surgical Replacement and Transcatheter Aortic Valve Implantation (SURTAVI)</td>
<td>To investigate the safety and efficacy of transcatheter aortic valve implantation (TAVI) in patients with severe, symptomatic aortic stenosis (AS) at intermediate surgical risk by randomizing patients to either surgical aortic valve replacement (SAVR) or TAVI with the Medtronic CoreValve® System.</td>
</tr>
<tr>
<td><strong>AORTIC DISEASE</strong></td>
<td></td>
</tr>
<tr>
<td>Post-Approval Study of the RELAY Plus® Thoracic Stent-Graft with TRANSPORT® Delivery System in Patients with Thoracic Aortic Aneurysms and Penetrating Ulcers</td>
<td>To assess long-term performance of the device, which will be evaluated by the rate of aneurysm-related mortality at 5 years post-implant. Aneurysm-related mortality is defined as death from rupture of the descending thoracic aortic aneurysm (DTAA) or penetrating aortic ulcer (PAU), or from any procedure intended to treat the DTAA or PAU.</td>
</tr>
<tr>
<td>The International Registry of Acute Aortic Dissection (IRAD) Protocol</td>
<td>To elucidate information about acute aortic dissection patients and disseminate findings through peer-reviewed publications to corroborate clinician behavior and societal guidelines concerning this disease.</td>
</tr>
<tr>
<td><strong>HEART RHYTHM DISORDERS</strong></td>
<td></td>
</tr>
<tr>
<td>NAVIGATE X4</td>
<td>To gather data to establish the safety, performance and effectiveness of the ACUITY™ X4 quadripolar coronary venous leads and the RELIANCE 4-FRONT™ ventricular defibrillation leads to satisfy FDA requirements for premarket submission. Additionally, data from this study will be used to support postmarket approval requirements for the ACUITY X4 and RELIANCE 4-FRONT leads.</td>
</tr>
<tr>
<td>VEST - Evaluation of ACUITY™ X4 Quadripolar Coronary Venous Leads and RELIANCE™ 4-FRONT Defibrillation Leads</td>
<td>To gather data to establish the safety, performance and effectiveness of the ACUITY™ X4 quadripolar coronary venous leads and the RELIANCE 4-FRONT™ ventricular defibrillation leads to satisfy FDA requirements for premarket submission. Additionally, data from this study will be used to support postmarket approval requirements for the ACUITY X4 and RELIANCE 4-FRONT leads.</td>
</tr>
<tr>
<td>HEART RHYTHM DISORDERS (continued)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>REFINE ICD</strong></td>
<td>Parallel-design, prospective, multicenter, international, randomized controlled trial in which subjects will be randomized 1:1 to treatment (ICD) vs. control therapy. Subjects with LVEF values 36% to 50%, abnormal TWA and impaired HRT measured 2 to 15 months post-MI will be randomized to an ICD vs. no ICD.</td>
</tr>
<tr>
<td><strong>ENHANCE CRT</strong></td>
<td>To analyze the effect of LV lead pacing location (guided via QLV measurement vs. standard of care approach) in the non-LBBB HF patient population. This pilot study will provide preliminary feasibility data on QLV-based implant strategy in a non-LBBB patient population.</td>
</tr>
<tr>
<td><strong>Micra CAS</strong></td>
<td>To provide access to the Micra™ Transcatheter Pacing System to a wider group of patients at an earlier stage in the regulatory approval process. Micra™ is a miniaturized single-chamber pacemaker system that is delivered via catheter through the femoral vein and is implanted directly inside the right ventricle of the heart. The Micra device eliminates the need for a device pocket and insertion of a pacing lead, thereby potentially eliminating complications associated with traditional pacing systems while providing similar pacing benefits.</td>
</tr>
<tr>
<td><strong>STAR-VT</strong></td>
<td>To demonstrate that scar-based VT ablation in subjects who are clinically indicated for new ICD or CRT-D implantation and are at high risk of ICD shock because of having spontaneous MMVT or inducible MMVT during EP or NIPS study results in a superior clinical outcome compared to routine drug therapy while maintaining an acceptable safety profile. The FlexAbility™ Ablation Catheter (St. Jude Medical) shall be used for ablation as indicated.</td>
</tr>
<tr>
<td><strong>EMBLEM Subcutaneous Implantable Defibrillator family (EMBLEM S-ICD)</strong></td>
<td>To assess the 18-month incidence of shocks in subjects implanted with the EMBLEM Subcutaneous Implantable Defibrillator (S-ICD) programmed with zone cutoffs at 200 bpm and 250 bpm. The primary endpoint is the shock free rate at 18 months compared to a performance goal of 87.2%.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HEART FAILURE STUDIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CardioMEMS HF Post Approval Study</strong></td>
</tr>
<tr>
<td><strong>RELAX-AHF-2</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERIPHERAL STUDIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST-CLI Trial</strong></td>
</tr>
<tr>
<td><strong>SAFE-DCB U.S. Registry</strong></td>
</tr>
</tbody>
</table>
Northwell Health’s mission is to educate future generations of health care professionals and to actively participate in the search for new advances in medicine through biomedical research. Reflecting this, we offer 115 residency and fellowship programs with more than 1,500 clinicians in training. Our many cardiovascular training programs include the following:

**Cardiovascular and Thoracic Surgery Residency**

Our residency at Hofstra Northwell School of Medicine boasts one of the most experienced cardiac surgical teams in the region. We are host to the only accredited cardiothoracic residency on Long Island and one of only five in the New York metropolitan area.

The surgeons and staff at Northwell Health believe the best way to train cardiothoracic surgeons is through an integrated, hands-on approach with increasing levels of responsibility. With this in mind, Northwell Health offers a comprehensive thoracic surgery residency program. Residents have the opportunity to train at locations including North Shore University Hospital, LIJ Medical Center and Southside Hospital. These three centers serve as advanced diagnostic and treatment centers for cardiovascular and thoracic disease.

The program offers integrated experience in clinical cardiothoracic surgery, including pediatric cardiothoracic surgery, general thoracic surgery and adult cardiac surgery.
**Integrated Thoracic Surgery Residency**

The Hofstra Northwell School of Medicine integrated thoracic surgery training program is offered through LIJ Medical Center, North Shore University Hospital and Southside Hospital. The program provides experience in general surgery, medical subspecialties, clinical cardiothoracic surgery, including pediatric cardiothoracic surgery, general thoracic surgery and adult cardiac surgery. Residents also take part in clinical decision-making in preoperative and postoperative care.

**Cardiology Fellowships**

At Northwell Health, the Department of Medicine’s cardiovascular disease fellowship program combines innovative technologies, internationally recognized faculty, and diverse patient populations from Lenox Hill Hospital, LIJ Medical Center, North Shore University Hospital and Staten Island University Hospital. These tertiary care centers provide a world-class training program and participate in the development of new technologies and advances in medical treatment for cardiovascular disease patients.

Our fellowship program provides exceptional training in all of the clinical and procedural areas related to cardiovascular disease. Moreover, all fellows will have the opportunity to participate in both clinical and basic science research protocols. A busy ambulatory fellows practice allows our trainees to care for groups of patients throughout their program.

Fellows participate in quality and performance improvement committees throughout the hospitals. One of our main goals is to teach state-of-the-art approaches and techniques to prepare trainees to work at the forefront of their field.
Interventional Cardiology Fellowships

The interventional cardiology fellowship program at Lenox Hill Hospital, LIJ Medical Center, North Shore University Hospital and Staten Island University Hospital offers core procedural experience in coronary arteriograms, ventriculography, hemodynamics, intravascular ultrasound, intracoronary Doppler flow and pressure monitoring. The program also provides experience in interventional techniques such as balloon angioplasty, stent implantation, saphenous vein graft and arterial graft interventions, distal embolic protection during angioplasty and urgent angioplasty for acute coronary syndromes, among others.
Fellows gain experience in the management of procedural complications and the appropriate use of mechanical and pharmacological agents. Additionally, they acquire training in a full range of arterial vascular access techniques. Each fellow also treats an array of coronary lesion morphologic subsets. Moreover, all fellows have the opportunity to participate in clinical research projects.

Our fellowship program exposes fellows to a wide range of coronary interventions including elective coronary angioplasty and stent, primary acute MI intervention and niche procedures such as Rotablator™, AngioJet™, FilterWire EZ™ and GuardWire®. Both femoral and radial approaches are routinely used. For interested fellows, there is the option of learning peripheral vascular interventional techniques and adult congenital procedures such as atrial septal defect and patent foramen ovale closure. The learning experience is primarily through one-on-one participation in an individual procedure with an interventional attending.