Ventricular assist device

A **ventricular assist device (VAD)** is an electromechanical device for assisting cardiac circulation, which is used either to partially or to completely replace the function of a failing heart. The function of a VAD differs from that of an artificial cardiac pacemaker in that a VAD pumps blood, whereas a pacemaker delivers electrical impulses to the heart muscle. Some VADs are for short-term use, typically for patients recovering from myocardial infarction (heart attack) and for patients recovering from cardiac surgery; some are for long-term use (months to years to perpetuity), typically for patients suffering from advanced heart failure.

VADs are designed to assist either the right ventricle (RVAD) or the left ventricle (LVAD), or to assist both ventricles (BiVAD). The type of VAD implanted depends on the type of underlying heart disease, and on the pulmonary arterial resistance, which determines the workload of the right ventricle. The left ventricular assist device (LVAD) is the most common device applied to a defective heart (it is sufficient in most cases; the right side of the heart is then often able to make use of the heavily increased blood flow), but when the pulmonary arterial resistance is high, then an (additional) right ventricular assist device (RVAD) might be necessary to resolve the problem of cardiac circulation. If both an LVAD and an RVAD is needed a BiVAD is normally used, rather than a separate LVAD and RVAD.

Normally, the long-term VAD is used as a bridge to transplantation (BTT) — keeping the patient alive, and in reasonably good condition, and able to await heart transplant outside of the hospital. Other "bridges" include bridge to candidacy, bridge to decision, and bridge to recovery. In some instances VADs are also used as destination therapy (DT). In this instance, the patient will not undergo a heart transplantation and will rely on the VAD for the remainder of his or her life.[1][2]

VADs are distinct from artificial hearts, which are designed to assume cardiac function, and generally require the removal of the patient's heart.

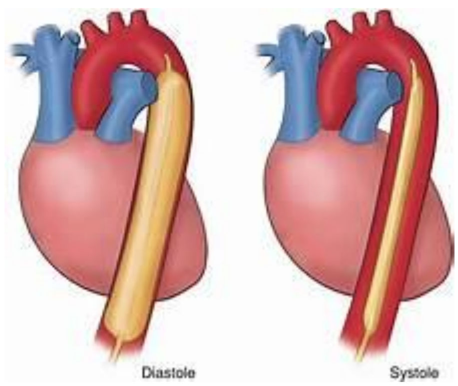
Cardiac Assist Devices:

During the latter half of the twentieth century, physicians have had the capability to support the circulation with mechanical devices. Gibbon's efforts led to the first successful clinical use of cardiopulmonary bypass (CPB) in 1952.[16] This heart-lung bypass system was rapidly employed to temporarily support part or all of the circulation during cardiac operations. However, early efforts to support acute myocardial infarction shock patients with CPB were unsuccessful,[37] giving rise in the early 1960s to the concept that CPB was not well suited for the treatment of patients with cardiogenic shock who would require support for several days to weeks. It was obvious that another method of temporary mechanical circulatory support was needed to maintain patients long enough to allow myocardial recovery. Conversely, CPB in the form of extracorporeal membrane oxygenation (ECMO) was used successfully in the mid-1970s for the treatment of severe respiratory insufficiency in infants and children. For this indication, the durations of support were usually less than 10 days. More recently, peripheral CPB has been used extensively to resuscitate children and adults during episodes of cardiac arrest, but durations of support for this indication are usually less than 72 hours.

Initial efforts with ventricular assist devices (VADs) were concentrated at designing integrated systems that would provide isolated left ventricular support.6, 7 In 1968 diastolic counterpulsation with an intra-aortic balloon pump (IABP) was developed, and these devices were commercially available by the early 1970s.19, 27 The introduction of the IABP reduced the need for temporary VADs, but there remained a group of critically ill patients with very low cardiac outputs in whom IABPs were ineffective.

Throughout the decade of the 1970s, technologic refinements led to more elaborate and innovative devices. These systems could provide assistance to a failing ventricle for longer periods of time with less blood component damage. These second-generation systems included external and internal pneumatic VADs, pneumatic total artificial hearts (TAHs), electrical left ventricular assist devices (LVADs), percutaneous CPB, and an implantable continuous flow device.2, 3, 9, 15, 28, 31, 32, 34 Over the last decade, improvements in patient selection as well as clinical and device management have led to growth in the use of mechanical circulatory support. In the bridge to transplant patient population, survival rates have increased and morbidity rates are on the decline.25, 26, 29, 36 A small group of patients have been successfully supported for longer than 1 year with different devices, and successful perfusions of longer than 3 months are now commonplace. Patients supported with portable/wearable LVADs have been discharged from the hospital to await cardiac transplantation. Some of these patients have returned to work with the VAD in place. In some United States centers and in centers outside the United States, VADs have been used as an alternative to cardiac transplantation.10, 14, 21, 22 The indications for VAD support are varied, and several devices are now commercially available. Other systems are available with special exemption from the Food and Drug Administration (FDA) for investigational use. Some devices have been designed for very specific, limited circumstance, whereas others are capable of multiple applications.

Intra-aortic balloon pump



The **intra-aortic balloon pump (IABP)** is a mechanical device that increases myocardial oxygen perfusion and indirectly increases cardiac output through afterload reduction. It consists of a cylindrical polyurethane balloon that sits in the aorta, approximately 2 centimeters (0.79 in) from the left subclavian artery.[1] The balloon inflates and deflates via counter pulsation, meaning it actively deflates in systole and inflates in diastole. Systolic deflation decreases afterload through a vacuum effect and indirectly increases forward flow from the heart. Diastolic inflation increases blood flow to the coronary arteries via retrograde flow. These actions combine to decrease myocardial oxygen demand and increase myocardial oxygen supply.

Indications

The following situations may benefit from this device.[2][3]

- Cardiogenic shock when used alone as treatment for myocardial infarction. 9-22% survive the first year.
- Reversible intracardial mechanical defects complicating infarction, i.e. acute mitral regurgitation and septal perforation.
- Unstable angina pectoris benefits from counterpulsation.
- Post cardiothoracic surgery—most common and useful is counterpulsation in weaning patients from cardiopulmonary bypass after continued perioperative injury to myocardial tissue.
- Preoperative use is suggested for high-risk patients such as those with unstable angina with stenosis greater than 70% of main coronary artery, in ventricular dysfunction with an ejection fraction less than 35%.
- Percutaneous coronary angioplasty
- In high risk coronary artery bypass graft surgery where cardiopulmonary bypass time was shortened, as well as during intubation period and hospital stay.
- Thrombolytic therapy of acute myocardial infarction.

Contraindications

Aortic pressure curve in the presence of an intra-aortic balloon pump

Vital parameters recorded during a 1:2 counter-pulsation

Absolute contraindication

The following conditions will always exclude patients for treatment:

- Severe aortic valve insufficiency
- Aortic dissection
- Severe aortoiliac occlusive disease and bilateral carotid stenosis

Relative contraindication

The following conditions make IABP therapy inadvisable except under pressing circumstances:[2]

- Prosthetic vascular grafts in the aorta
- Aortic aneurysm
- Aortofemoral grafts
- Sepsis

Complications

Since the device is placed in the femoral artery and aorta it could provoke ischemia, and compartment syndrome. The leg is at highest risk of becoming ischemic if the femoral artery it is supplied by becomes obstructed. Placing the balloon too distal from the aortic arch may induce occlusion of the renal artery and subsequent kidney failure. Other possible complications are cerebral embolism during insertion, infection, dissection of the aorta or iliac artery, perforation of the artery and bleeding in the mediastinum. Mechanical failure of the balloon itself is also a risk which entails vascular surgery to remove under that circumstance. After balloon removal there is also a risk of 'embolic shower' from micro clots that have formed on the surface of the balloon, and can lead to peripheral thrombosis, myocardial ischemia, hemodynamic decompensation, and late pseudoaneurysm. In the preferred embodiment of the present invention, the construction of a dynamic aortic blood pump or mechanical auxiliary ventricle (hereafter MAV) includes an elongate semi-rigid shell member having a concave inner surface and a flexible membrane integrally bonded to the outer peripheral surface of the shell member to define a chamber between the concave inner surface and the membrane. When the MAV is sutured into the descending aorta in the thoracic or abdominal cavity it will present an elongate elliptical septum (the membrane) which is caused to expand into the aorta under fluid pressure during an inflation cycle and displaces blood with an elongate semi-prolate spheroid bulging of the membrane projecting from the shell perimeter. In the deflation cycle the hydraulic (aortic blood) forces on the membrane typically cause the central portion of the membrane (the most supple region with the maximal aortic lumen intrusion) to collapse toward the shell concavity first. The fluid pressure inlet (outlet) tube leading to the internal passageway of the chamber is located centrally and could be prematurely occluded by the aforementioned membrane collapsibility (preventing full deflation). Prior devices, such as that disclosed in U.S. Pat. No. 4,630,597 disclose the use of a plurality of grooves that extend from the opening of the internal passage that prevent the passage from being prematurely occluded. Another prior known device disclosed in U.S. Pat. No. 4,051,841 teaches the use of a system of longitudinal filaments to prevent fluid entrapment under similar circumstances

Mechanical auxillary ventricle blood pump with reduced waist portion

The pumping efficiency of the MAV is substantially reduced by this partial deflation, created when a portion of the air in the chamber is trapped by the premature occlusion of the inlet passage. The full stroke typical displacement capability of 35 cc (cubic centimeters) based on the membrane seating on the shell concavity would be reduced by the percentage volume of air entrapment were it not for the system of grooves that extended over the length of the MAV as disclosed in U.S. Pat. No. 4,630,597.

However, the system of grooves creates long term problems of membrane durability associated with the localized flexing of the membrane at each groove site, when it is hydraulically driven against the shell concavity (by aortic blood pressure) especially at high pulsing rates. The shell and membrane materials tend to be low slip, high grab substances that will create localized rubbing and heating along the groove ridges and when combined with the plurality of groove flexing and stretch sites can lead to membrane distortion and failure even in the presence of a surface lubricant. Furthermore, while the grooves prevent occlusion of the air outlet passage the grooves can create some delay in deflation by requiring exhausting air to travel through the long groove passageways formed if the membrane seats first in the central region of the shell concavity. A related problem concerns “slapping” or the thumping associating with the supple membrane being accelerated against the shell concavity.

The problems associated with occlusion prevention groove geometry in the MAV are eliminated by the present invention, which does not employ a groove system but makes use of preferential stretching modes built into the membrane geometry and which is conveniently referred to as a “waist”. The waist consists of carefully graduated narrowing of the membrane mid-body that shortens the arcuate cord length so as to prevent the membrane from bottoming out against the shell concavity in the mid-zone of the MAV and thus permitting the unhindered exhausting of air from all of the MAV chamber. In this mode of operation occlusion of the air outlet is prevented, without resort to a groove system and its associated problems.

The MAV is essentially a bladder, and bladders along with elastomeric diaphragms find wide application outside of heart assist applications. Bladder and diaphragm devices are used as clamping and jacking or lifting devices as well as pumping and cushioning devices and as low pressure sensors. The problem of exhaust air entrapment is a universal one and the "waist" concept is believed to be applicable especially for bladders of a longitudinal configuration which are in widespread usage.

A dynamic aortic patch or blood pump according to the present invention assists cardiac function during a cardiac cycle of a patient when positioned with respect to an aorta of the patient. The dynamic aortic patch or mechanical auxiliary ventricle includes an elongate semi-rigid shell having a contoured, concave inner surface terminating at a peripheral side edge. At least one passage extends through the shell to define an opening in the inner surface. A flexible membrane is continuously bonded to the shell adjacent the peripheral side edge to define an enclosed inflatable chamber in communication with the passage. The membrane has a reduced waist portion defining a membrane tension zone adjacent the opening of the passage into the chamber to prevent occluding the entrance while deflating the chamber.

The present invention also includes an apparatus for forming the flexible membrane for the dynamic aortic patch. The apparatus includes an elongate mandrel having a shape defined by substantially flat major surfaces opposite from one another and terminating at a rounded peripheral side edge extending between the major surfaces. The side edge is contoured and curved to define partial ellipses at both ends and a reduced waist portion adjacent a midway position. The mandrel is adapted to receive the thin, flexible, heat setable, membrane over one of the flat major surfaces and wrapped around the side edge a sufficient distance to form a flange adjacent to the opposite flat major surface. At least one clip can also be provided for holding the membrane in position during a heating process to set a defined shape into the memory of the membrane, where the shape corresponds to the shape of the mandrel.

FEATURE TRENDS IN ASSISSTIVE TECHNOLOGY

1. Mainstream Companies Following Inclusive Design

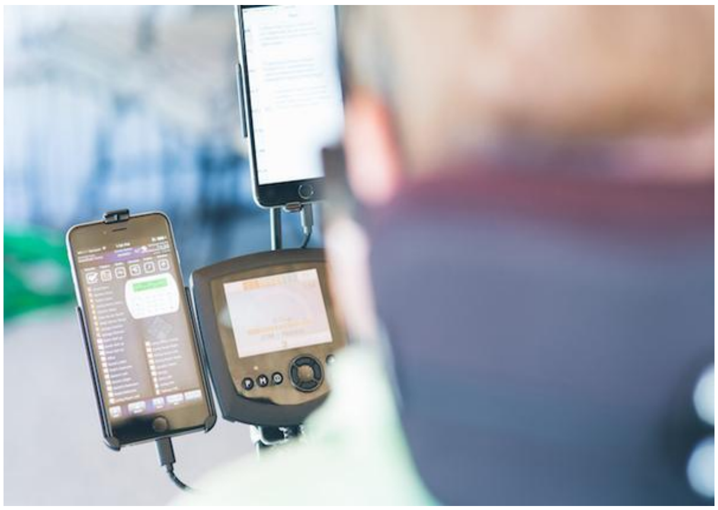
Inclusive design refers to design of products, services and environments that considers the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference. Here, we’re not just talking about local restaurants who install ramps to comply with accessibility standards and include wheelchair users in enjoying their service but also big-name tech companies that have been selling to the general public for a long time.

Microsoft products contain several accessibility features including speech recognition and audio description but have also introduced innovative tools including Narrator which allows users to interact with the interface without using a display or viewing a screen. Products will soon be compatible with Braille displays from more than 35 manufacturers and we can expect more to come as Microsoft claims to convene two to three inclusive design projects every month. Microsoft even has a blog that regularly produces assistive technology and accessibility-related content.

Apple has become a household name in smartphone accessibility with features like Switch Control, VoiceOver and Live Listen integrated into all of their devices and are announcing new versions and new features into their operating systems at each annual conference. They even launched a campaign highlighting Apple users with disabilities.

2. Portability

Accessing technology in public spaces is an important step towards gaining independence for individuals with disabilities. Assistive technology has finally shifted away from requiring users to own a single expensive device for one purpose, and now, many devices including the tecla-e can be used to perform almost all daily activities. Since tecla-e gives people with upper-body mobility impairments the ability to fully access smart devices, users can send and receive emails and text messages, browse the web, watch videos, launch and use apps, read books, change the TV channel or turn the heat up, make (or hang up) phone calls at any time. That's a lot of things you can do with just one device.



Gone are the days of connecting devices with long cables and using floppy discs to install applications. Now, a lot of assistive technology software is available as downloadable applications that can be used whenever and wherever you are. Some are even used specifically for when users with disabilities are exploring their environment, including AccessNow, which uses an interactive map to pinpoint locations in your area that are wheelchair accessible, helping users plan ahead and know what to expect from their outing.

3. Voice Assistants

The most widely used and developed voice assistants are the ones integrated into personal technologies like Apple's Siri, Microsoft Cortana, Google Assistant and Amazon Alexa. Artificial intelligence software like these can do almost anything a user asks it to do including text or call a friend, book an appointment into the calendar, check the weather and so much more just through speech. Voice assistants reduce many barriers to accessing mobile technologies for individuals with physical disabilities, vision or hearing loss, but currently have not made strides in creating access for individuals with speech impairments. As they become more widely seen as a necessary daily aid, we hope to see voice assistants become smarter and even more accessible.

4. DIY

From low to high tech devices, there are millions of do-it-yourself assistive technology inspirations and instructions on the Internet that are being produced and used by individuals with disabilities, special education teachers, occupational therapists and speech pathologists.

DIALYSIS FOR KIDNEY

What is dialysis?

A healthy person's kidneys filter around 120 to 150 quarts of blood each day. If the kidneys are not working correctly, waste builds up in the blood. Eventually, this can lead to coma and death.

The cause might be a chronic, or long-term condition, or an acute problem, such as an injury or a short-term illness that affects the kidneys.

Dialysis prevents the waste products in the blood from reaching hazardous levels. It can also remove toxins or drugs from the blood in an emergency setting.

Types of dialysis

There are different types of dialysis.

The three main approachesTrusted Source are:

- Intermittent hemodialysis (IHD)
- Peritoneal dialysis (PD)
- Continuous renal replacement therapies (CRRT)

The choice will depend on factors such as the patient's situation, availability, and cost.

Intermittent hemodialysis

In hemodialysis, the blood circulates outside the body. It goes through a machine with special filters.

The blood comes out of the patient through a flexible tube known as a catheter. The tube is inserted into the vein.

Like the kidneys, the filters remove the waste products from the blood. The filtered blood then returns to the patient through another catheter. The system works like an artificial kidney.

Those who are going to have hemodialysis need surgery to enlarge a blood vessel, usually in the arm. Enlarging the vein makes it possible to insert the catheters.

Hemodialysis is usually done three times a week, for 3 to 4 hours a day, depending on how well the kidneys work, and how much fluid weight they have gained between treatments.

Hemodialysis can be done in a special dialysis center in a hospital or at home.

People who have dialysis at home, or their caregiver, must know exactly what to do.

If a person does not feel confident doing dialysis at home, they should attend sessions at the hospital.

Home hemodialysis is suitable for people who:

- have been in a stable condition while on dialysis
- do not have other diseases that would make home hemodialysis unsafe
- have suitable blood vessels for inserting the catheters
- have a caregiver who is willing to help with hemodialysis

The home environment must also be suitable for taking hemodialysis equipment.

Peritoneal dialysis

While hemodialysis removes impurities by filtering the blood, peritoneal dialysis works through diffusion.

In peritoneal dialysis, a sterile dialysate solution, rich in minerals and glucose, is run through a tube into the peritoneal cavity, the abdominal body cavity that surrounds the intestine. It has a semi-permeable membrane, the peritoneal membrane.

Peritoneal dialysis uses the natural filtering ability of the peritoneum, the internal lining of the abdomen, to filter waste products from the blood.

The dialysate is left in the peritoneal cavity for some time, so that it can absorb waste products. Then it is drained out through a tube and discarded.

This exchange, or cycle, is normally repeated several times during the day, and it can be done overnight with an automated system.

The elimination of unwanted water, or ultrafiltration, occurs through osmosis. The dialysis solution has a high concentration of glucose, and this causes osmotic pressure. The pressure causes the fluid to move from the blood into the dialysate. As a result, more fluid is drained than is introduced.

Peritoneal dialysis is less efficient than hemodialysis. It takes longer periods, and it removes around the same amount of total waste product, salt, and water as hemodialysis.

However, peritoneal dialysis gives patients more freedom and independence, because it can be done at home instead of going to the clinic several times each week. It can also be done while traveling with a minimum of specialized equipment.

Before starting peritoneal dialysis, the patient needs a small surgical procedure to insert a catheter into the abdomen. This is kept closed off, except when being used for dialysis.

There are two main types of peritoneal dialysis:

Continuous ambulatory peritoneal dialysis (CAPD) requires no machinery, and the patient or a caregiver can do it.

The dialysate is left in the abdomen for up to 8 hours and then replaced with a fresh solution straight away. This happens every day, four or five times per day.

Continuous cyclic peritoneal dialysis (CCPD)

Continuous cyclic peritoneal dialysis (CCPD), or automated peritoneal dialysis uses a machine to exchange the fluids. It is generally done every night, while the patient sleeps.

Each session lasts from 10 to 12 hours. After spending the night attached to the machine, most people keep the fluid inside their abdomen during the day. Some patients may need another exchange during the day.

Peritoneal dialysis is a suitable option for patients who find hemodialysis too exhausting, such as elderly people, infants, and children. It can be done while traveling, so it is more convenient for those who work or attend school.

Continuous renal replacement therapy

Dialysis can be intermittent or continuous.

While a session of intermittent dialysis lasts for up to 6 hours, continuous renal replacement therapies (CRRT) are designed for 24-hourTrusted Source use in an intensive care unit (ICU).

There are different types of CRRT. It can involveTrusted Source either filtration or diffusion. It is better tolerated than intermittent dialysis, because the solute or fluid removal is slower. This leads to fewer complications, for example, a lower chance of hypotension.

Temporary dialysis

Sometimes dialysis is given for a limited period of time.

People who may benefit from temporary dialysis include those who:

- Have a sudden, or acute, kidney condition
- Have consumed toxic substances or taken a drug overdose
- Have had a traumatic injury to the kidney
- Have chronic heart diseaseTrusted Source

Risks and complications include:

- hypotension
- cramps
- nausea and vomiting
- headache
- chest pain
- back pain
- itchiness
- fever and chills

In some cases, the kidneys recover and do not need further treatment.

Does dialysis replace the kidneys?

Dialysis helps patients whose kidneys have failed, but it is not as efficient as a normal kidney. Patients who receive dialysis need to be careful about what and how much they drink and eat, and they need to take medication.

Many people who have dialysis can work, lead normal lives, and travel, as long as dialysis treatment is possible at the destination.

Women who have dialysis normally have difficulty becoming pregnant. There will be a higher level of waste products in the body than there are with normal kidneys. This interferes with fertility.

Women who do become pregnant while on dialysis will probably need increased dialysis during the pregnancy. If a woman has a successful kidney transplant, her fertility should return to normal.

Dialysis has some effect on male fertility, but less than on female fertility.

Symptoms of kidney failure

Blood or protein in the urine can be a sign of kidney failure.

Chronic kidney failure happens gradually. Even if just one kidney works, or both work partially, normal kidney function is still possible. It can be a long time before the symptoms of a kidney condition appear.

When symptoms do occur, they often vary between individuals, making it harder to diagnose kidney failure quickly.

Symptoms of kidney failure may include:

- Fatigue, or tiredness
- Increasingly frequent need to urinate, especially at night
- Itchy skin
- Erectile dysfunction, when a man has difficulty sustaining an erection
- Nausea
- Shortness of breath
- Water retention, leading to swollen feet, hands, and ankles
- Blood in urine
- Protein in urine

A sudden injury can cause kidney failure. When it does, symptoms tend to appear faster and progress more rapidly.

Anemia is common in people with chronic kidney disease. It can happen when levels of erythropoietin (EPO) are low. EPO is a produced by the kidneys, and it helps the body produce red blood cells. When the red blood cell count is low, it is called anemia.

Side effects

People who depend on kidney dialysis may experience:

- Muscle cramps
- Itchy skin, often worse before or after a procedure
- Low blood pressure, particularly in people with diabetes
- Sleep problems, sometimes due to itchiness, restless legs, or small breaks in breathing, known as apnea
- Fluid overload, so patients must consume a fixed amount of fluid each day
- Infections or ballooning at the access site for dialysis
- Depression and mood fluctuations

Kidney disease is a serious condition. In people with chronic kidney failure, the kidneys are unlikely to recover, but dialysis can enhance wellbeing and prolong life for up to 20 years or more.

A Virtual Reality Training System for Helping Disabled Children

1 . Introduction

Deficiencies in hand dexterity present challenges to disabled children in performing various activities of daily living (ADLs). The impairment does not only affect their self-care abilities but could also lead to low self-esteem and other psychological impacts. Special schools for the physically disabled have been providing special education and rehabilitation services to the students. In ADL training, occupational therapists strive to improve the students' self-care abilities and maximize their level of independence.

Conventional ADL training is conducted in real or physically simulated environments through various training modalities [1], including behavioural approach for skill acquisition, neuro-developmental approach, conductive education, constraininduced movement therapy and biofeedback. However, the training is associated with potential issues concerning safety, logistics, efficiency and cost. Besides, the approaches are not readily customizable for people with different levels of disability, where therapists are required to focus on meeting specific training needs rather than teaching technical strategies. In this regard, we propose to use virtual reality (VR) technology and haptic user interface to complement conventional ADL training, so as to improve the teaching and learning of self-care skills. By leveraging these technologies, ADL training can be conducted in computer-simulated environments which can offer various advantages, e.g. flexible and realistic settings in virtual environment, customizability, quantitative assessment, safe training on risk-prone skills and repetitive training.

2 . The benefits of VR for children with disabilities

Benefits of VR have been reported for training and skills enhancement of children with disabilities. Children with disabilities have the opportunity to learn and practice new skills in VEs such as crossing streets or going shopping without the worry of potential injury or fear of embarrassment . VEs can also be designed to meet the specific training needs of each child. For example, the number of stimuli presented to a child who has autism can be controlled , or virtual wheelchair training for children with severe physical disabilities can be moderated. Benefits have also been noted for the use of VR in rehabilitation, such as for applications for cognitive assessment physical assessment , and training in motor or cognitive functioning . Social benefits for children with disabilities have also been attributed to the use of VR. Along with a sense of self-control and mastery, VR has allowed children to communicate with other children sharing similar disabilities or diseases . Alternatively, through the use of an avatar (a persona that the user chooses to adopt in a virtual world), the child can focus on their sense of self and not their disability. VR may also offer a new perspective for children and the opportunity to experience different points of view or assume different identities . The anonymity associated with communicating with other networked users within a VE puts the child on an equal footing and provides a social outlet for children who might otherwise be isolated from their peers . However, Wilson and his colleagues suggest that the very sense of freedom and well-being felt in VEs may in fact cause the user to withdraw from real-life social situations, a result of quasi-addiction to this artificial reality.

3 . Customizing VR to meet the needs of children with disabilities

The properties of VR, in particular its malleability, make it a versatile medium for the development of applications that can be customized to meet the needs of children with disabilities. The characteristics of the VE can be modified to include or exclude certain categories of stimuli depending on the goal of the program [9]. This adaptability helps promote an optimal interaction for children with disabilities. VR allows children with sensory impairments to experience what would normally be difficult or impossible for them by transposing information from the affected sensory modality into information that can be perceived by the senses which are intact. An example is a VE that uses auditory and/or tactile cues for children who are blind [15].VEs can also be adapted to suit different learning styles. For instance, auditory information can be provided in a greater proportion for the “acoustic learner” [14] as opposed to more visual information for the “visual learner” [4]. VEs developed for autistic children limit the number of stimuli presented, to encourage children to concentrate on a particular task [8]. The number of simultaneous stimuli can gradually be increased as the child’s time on task progresses, until the child can function at a level that mimics real-world settings. Similarly, learning experiences can be structured for children with learning difficulties to break down complex tasks into more simple components until the child masters the necessary skills . Another advantage of VR described by Wilson, Foreman & Stanton is that the need for semantics, symbols or language is virtually eliminated, due to the experiential nature of the learning process. This means that VR is more accessible to different categories of users who may benefit from learning a task in VR without the restrictions of traditional teaching methods.

4 . VR for minimizing the effects of a disability

Virtual reality can be viewed as an assistive technology, due to its potential to minimize the effects of disability. Lewis [18] conceptualized assistive technology as having two purposes: to improve a person's strengths in order to offset the effects of disability, or as an alternative way to accomplish a task that compensates for a disability. VR can serve as an assistive technology in both ways. For example, it is possible to translate gestures into speech [19], thereby taking advantage of good motor skills when speech is lacking. Alternatively, it allows a child to move within a VE even though in real-life this is physically impossible. VR technology also provides children with disabilities, greater access to many experiences. For instance, Nemire and Crane designed a VE that allowed students with cerebral palsy to access a virtual science laboratory using a specially adapted interface technology to target objects in 3-dimensional space. Other changes are occurring in VR technology to provide access to users who are blind via audio navigation. Max and Gonzalez are testing a system that they developed to convert models from the Internet into objects that can be felt using a haptic interface and localized using 3-D audio. They reported that a four-year-old girl who was blind was able to use the system to successfully localize sounds and recall the 3-dimensional scene over a course of several weeks. This type of technology may eventually open up the World Wide Web to individuals with visual impairments and supports the premise of VR as a tool for increasing access for children with disabilities.

5 . Role of VR in Skills

Enhancement and Training A lot of the work being done in VR for children with disabilities focuses on providing a simulated world which allows the child to train, practice or enhance their skills. The goal of this training can either be external, in order to practice skills which can be transferred to the real world, or internal, such as restoring or improving cognitive function through repetition and training [6,21]. Currently, the applications which focus on using virtual reality for enhancing skills and training for children with disabilities can be categorized as those which improve life skills, those which provide opportunities for mobility training, and finally, applications focusing on improving cognitive skills. Fostering independence, full participation and access, and a sense of control and mastery, are the main rehabilitative goals for children with disabilities. Much of the work being done for children with disabilities in VR has focused on these goals in concrete ways, such as training to shop independently, ride public transportation, and safely cross streets.