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Development of the Virtual PTCA system.

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Abstract:

By increase of disease of circulatory system, necessity of heart vascular intervention increases. Because intervention operation was developed recently, education system isn't established yet. In this study, the intervention education support system that virtual reality was applied was developed. Typical intervention includes Percutaneous transluminal coronary angioplasty (PTCA). PTCA is operation enlarging stenosis of coronary artery with a balloon through catheter. Technique letting stenosis cross with guide wire is one of most the difficult technique. Simulation was done of this technique with virtual reality. In virtual space, reconstitution was done of coronary artery, and virtual PTCA system was produced experimentally. An interesting system was produced experimentally as a system for training. After the system is compounded with expert system, usefulness will want to be raised more.

Key words: Percutaneous transluminal coronary angioplasty (PTCA), position sensor, virtual reality, Virtual PTCA, Remote operation,

1. Introduction

With aging of population composition in this country and alteration of disease structure, necessity of heart vascular intervention increases¹⁻³). Cardiovascular intervention is the operation which catheter was used¹⁻³). Accordingly this operation doesn't need thoracotomy. In this procedure, operation for the coronary artery disease like percutaneous transluminal coronary angioplasty (PTCA) is contained. Thoracotomy isn't carried out, and a heart-lung machine isn't used either. Effects same as coronary artery bypass graft (CABG) surgery can be obtained only with puncture of a blood vessel. Operation is possible to persons of advanced age. Thus these kinds of operation case increases by force very much.

However, as for the education systems, it isn't satisfactory yet, because it is method of new operation developed¹). Educational systems to teach the cardiovascular intervention specialist isn't established yet in Japan either^{4,5}). There is still a little expert of a veteran. It is danger that use a patient for education. It is discussed necessity of education system of cardiovascular intervention.

In this study, it was taken warning by this profile, and application of technology of virtual reality as a part of education system of cardiovascular intervention was tried. As typical operation of cardiovascular intervention, PTCA was picked up. With increase of a patient of coronary artery disease, indication example of PTCA increases remarkably in this country. Development of intervention education support system is tried mainly on PTCA, and it is reported because some result was obtained.

2. Profile of a system

Operative procedure of PTCA

In coronary artery disease, the *Acute myocardial infarction* and the *Angina pectoris* is contained. It is essentially generated by stenosis or occlusion of the coronary artery feeding

heart. As a cause of stenosis, there is arterial sclerosis or spasm of coronary artery. It is the coronary artery which was blockaded with mechanical stenosis by arterial sclerosis or myocardial infarct that surgery such as PTCA or coronary artery by-pass operation becomes necessary. Patients of myocardial infarct and unstable angina of acute stage carried in infirmary with ambulance become good indication.

It is that essence of operative procedure of PTCA enlarges stenosis part with balloon. Firstly, puncture is carried out in the femoral or the brachial artery with that purpose. Sheath letting catheter go in and out in arteria is inserted. Catheter is inserted in sheath, and coronary artery is contrasted. The coronary angiography examination which is usual examination is been same as at all to this place. If a specialist of circulatory organ is been, it is possible extremely safely.

In the procedure of PTCA, the PTCA catheter which had the balloon that stenosis part of arterial sclerosis expanded is used.

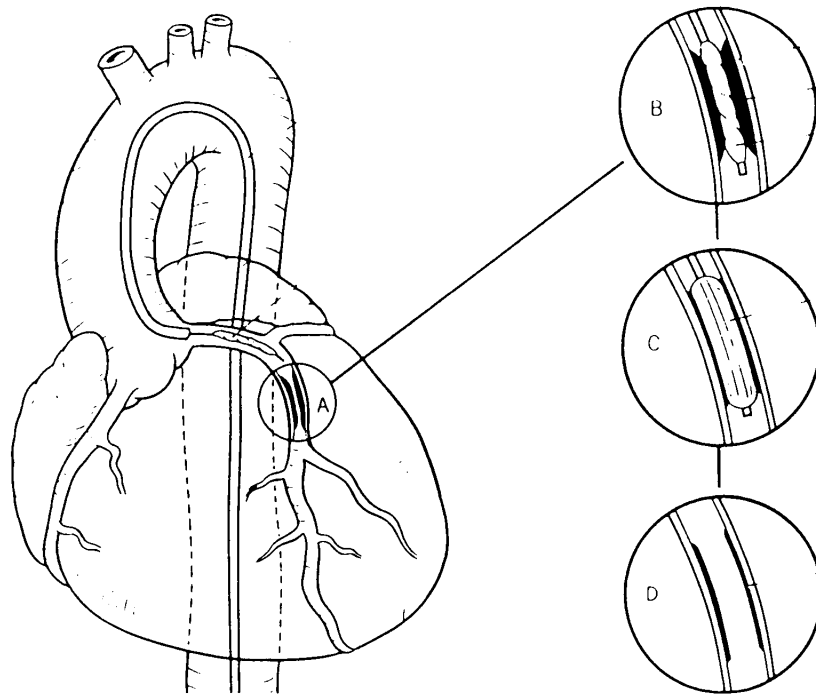


Fig.1 Schematic illustration of the PTCA procedures for the left anterior descending artery

PTCA catheter goes through the inside of catheter. Guide wire to pass the stenosis part goes through the inside of balloon catheter. In at hand of guide wire, torque device for manipulation is fixed. Guide wire is operated by operating torque device. We will let part of the arterial sclerosis which is responsible lesion cross with guide wire. And then, we will let pass stenosis part with PTCA balloon catheter after guide wire crossed. Therefore, we will let expand balloon. Contrast media is used for expansion as could confirm with roentgen ray. Pressure of expansion is different by pathological change, usually, balloon is expanded with 2-6 atmosphere. It is procedure only of this if has explained it.

Firstly, experience is necessary to operate guide wire. Secondary, if dissection of intima of coronary artery happens after PTCA, acute coronary occlusion is generated, and there may be the thing that myocardial infarct is become. Experience and storage of know-how is necessary to be operated on safely.

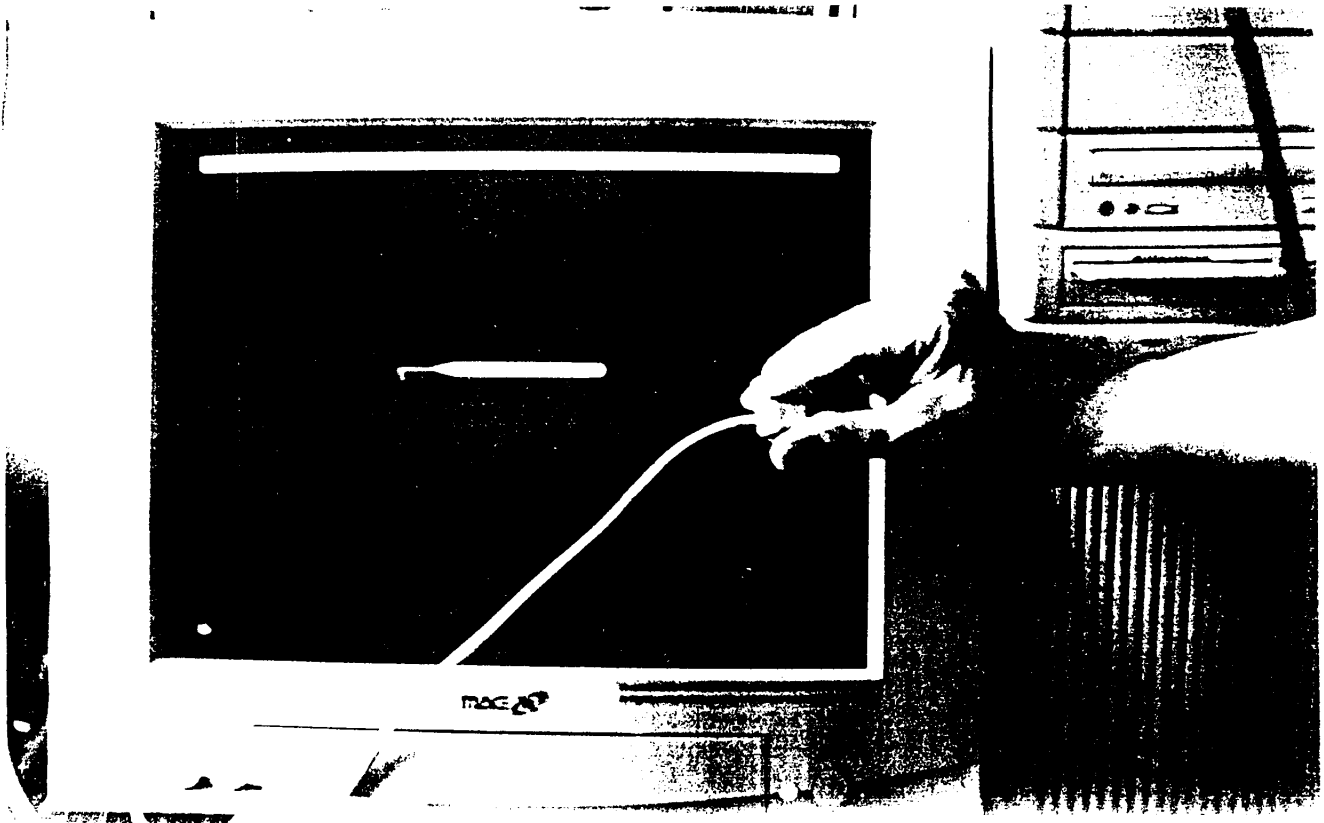
Constitution of a system

Experience of complicated procedure is necessary for PTCA as above. The spread of the elegant education system which a patient isn't used is necessary to let medical treatment grade improve. It is thought that this leads to the welfare of a people. In this study, we tried trial manufacture of PTCA education support system in the virtual coronary artery in the virtual space in the computer screen.

System used in this study were the three-dimensional position sensor 3-Space fastrak of Polhemus and personal computer PS-100J of Gateway2000 company. Three coils is had built-in the position sensor. Instrumentation of six degrees of freedom as x, y, z, pitch, yaw, roll is possible by electromagnetic induction. It is widely used system for the determination of the position in virtual reality.

One of the procedure which is the most difficult during thing of procedure of PTCA is

manipulation of torque device. In this study, manipulation of torque device was hit with focus, and a design of PTCA education support system was tried. Firstly, position sensor was imagined with torque device. The system that guide wire in virtual coronary artery constructed in virtual space was operated was produced experimentally. With that purpose, PTCA balloon of on wire system was constructed in virtual spaces we shown in fig.2.



*Fig.2 Photograph of a Virtual PTCA balloon on the virtual space on computer display.
On wire PTCA balloon and guide wire were manipulated with position sensor held
in the hand.*

We constructed the system which operated guide wire in the coronary artery which was constructed in virtual space by operating the position sensor which imagined it to torque device freely.

3. Result.

The virtual PTCA system which produced it experimentally was good for by operability. We were able to operate virtual PTCA balloon in virtual space by manipulation of the position sensor which imagined it to torque device freely. In procedure of real PTCA, manipulation is done by the relativity position between the Y connector and guide wire mounted an entrance of guide catheter with. By this manipulation, we can use guide catheter put in coronary artery entrance for a platform. Manipulation of guide wire is done for connector. Three manipulation is been if say easily. Three manipulation is push and a pull and rotations. The rotations included the clockwise rotation and the counterclockwise rotation. As total, four degrees of freedom is become. Thus, it is to become the thing that guide wire manipulation in PTCA was able to be simulated if takes shape in virtual space 4 degrees of freedom.

In a system produced experimentally, it took shape the degree of freedom of 4 of guide wire manipulation with space limited of space of virtual coronary artery blood vessel. With manipulation of torque device, we were able to operate virtual guide wire and virtual PTCA balloon. Accordingly it was judged to can simulate the guide wire manipulation which was one of the most difficult technology in procedure of PTCA as for virtual PTCA system produced experimentally this time. It was suggested that it was likely as one of the candidate of training system for a specialist.

4. Discussion

We produced virtual PTCA system experimentally as the one of the intervention education support system for the doctors who aimed at the specialists. The guide wire manipulation which was one of the most difficult procedure was realized in virtual space. Expert system is put together in this system. It is thought that an interesting system having amusement sensation as a part of specialist education comes true.

About medical science application of virtual reality, various trials has been done^{6,7)}. An interesting study as hyper hospital automation is carried out at Tokai university⁸⁾. Three dimensions solid architecture is necessary for in a field as neurosurgery area ⁹⁾. Application of virtual reality is tried from early stage in brain surgery comparatively in fields such as simulation surgery or tele operating system. In recent years, in the operation which utilized the endoscope which attracted attention, technology of virtual reality comes into the limelight.

However, advance of this field is still development the way in this country. Literature doing virtual reality with a key word is around 40 in this country now even if carries out medical science document retrieval. Rapid development after now is expected.

A field of cardiovascular intervention is the medical science field that image was applied. However, application isn't tried so long as we watch it with J-medline. As for intervention procedure as PTCA, direct visual judgment isn't done. Transillumination image by roentgen ray is basis of judgment. In recent years, ultrasound and technology of blood vessel endoscope is introduced in a field of PTCA ^{4,5)}. The virtual reality which is image-processing technique is easy to be applied most if think from a point of view that is taken.

In this study, virtual PTCA system was produced experimentally as education support system of a specialist. An elegant system new at all comes true by putting expert system together in this system. Of course, it is establishment of expert system that become important here. Operation such as PTCA, DCA, stent, thrombolysis is new technology. Because method and indication of operation includes discussion very much still, we can't think of homogeneous medical care is done. It is the present situation that even the know-how of operative procedure of intervention includes big difference when thinks about inclination of domestic medical care resources. Education support system as this study is hoped for powerfully. Indication and the know-how needs to be standardized before constructing expert system.

There is the probability too that tele operating system from remoteness comes true if applies a system developed. The procedure that movement of four the degree of freedom of guide wire was operated with torque device was formed in virtual space. Manipulation of torque device can be introduced into distance by Internet lines. Manipulator manipulation becomes possible using information of manipulation digitized with distant place. Guide wire operated goes into action in transillumination image by roentgen ray. Image information can be sent back by Internet lines equally. Tele operating PTCA system may be completed with information of coming and going in multimedia. However, by the current Internet line, there is a limit of information of a line. Tracing of image of real time is difficult, and tele operating from distance remains in prospective probability. This system is important in a district with many areas of medical care depopulation as Tohoku region. If tele operating system takes shape, operation of a skilled physician can be received even if world where. Development of this system is very important internationally.

It is discussed a problem about the influence that technology of virtual reality as head mounted display gives to the living body recently ^{10,11}). Such influence is belonging of the character which can become a problem when intervention procedure grows in long time. When it isn't tried, as for PTCA, a result isn't readable. Because coronary artery disease is aimed at, life is linked directly with if there is accident once. It can become it any time in long time. It is heard by a patient "whether a blood vessel doesn't explode". There is not bursting to outside of a blood vessel almost. As the complication which is danger, dissection of blood vessel intima to the inside of a blood vessel can happen. Technology of "stent" establishing a tunnel of wire with the inside of a blood vessel attracts attention of that purpose ^{4,5}). There is much that operation time is prolonged when complication is generated. In that event, influence of virtual reality to expert can't be ignored. Progress in this field is considered as urgent business, too.

Virtual PTCA of on wire system was produced experimentally in this study. Education support systems such as over the wire system and DCA or stent want to come true, too. A study of tele operating system through Internet line will be to go, too.

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