

# Biventricular pacemaker implantation with the BV Pulsera

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▲ Figure 1. The Cardiothoracic Centre in Liverpool, U.K.

The Cardiothoracic Centre Liverpool NHS Trust (Figure 1) is a large tertiary referral center in the north-west of England, and among the leading specialist heart and chest hospitals in the United Kingdom, with the largest pacemaker implantation unit in the country. It serves a population of over 2.8 million over a catchment area comprising metropolitan Liverpool, Merseyside, Lancashire, Cheshire, North Wales and the Isle of Man.

In terms of the volume of procedures, the Cardiothoracic Centre is probably the third largest center in the UK, and in terms of pacing procedures it is number one in the UK and among the top two or three in Europe. The hospital also has a leading position in radial coronary procedures, which virtually eliminate access site complications, and are characterized by a faster patient throughput and a shorter recovery time.

The Cardiothoracic Centre has nine operating rooms and four cath labs. A Philips Allura flat-panel system is currently being installed.

A team of five consultant cardiologists perform about 1200 implants a year, including a large volume of biventricular work.

In 2004 about 100 biventricular devices were implanted, out of a total of around 1000 in the U.K. The proportion of biventricular implants is steadily increasing.

As the BV Pulsera has been in use for six months, it will have been used for about 600 procedures. Of these, some 75 will be biventricular pacing, 80 will be ICD's, and about 20 will be extractions, some of which will have used laser equipment.

► In terms of pacing procedures, the CTC is No. 1 in the UK.



Pacemaker implantation generally takes place in a dedicated operating room, partly to avoid placing an extra load on the busy cath labs, and partly because the cath labs do not offer ideal facilities for pacemaker implantation.

Until quite recently, most of the pacemaker implantations performed were standard dual chamber pacing, requiring PA views and minimal fluoroscopy times, so a conventional surgical X-ray system was quite adequate. Lately, however, there has been a dramatic increase in the number of biventricular pacing procedures, where leads have to be inserted into the coronary sinus. This meant that the conventional X-ray system rapidly became inadequate. It was very difficult to visualize the angioplasty guide wires that went into the coronary sinus, especially when contrast agent was introduced. There were many problems of this type and the equipment frequently overheated. Some procedures had to be abandoned because it was not possible to follow the passage of the guide wires and leads into the coronary sinus, and other procedures had to be cancelled because of breakdowns. The whole situation became very unsatisfactory and frustrating.

Another disadvantage was that there were no adequate facilities in the operating room for storing images and playing them back, or for acquiring a roadmap that could be referred to later in the procedure.

There was an obvious need for a versatile, modern mobile unit. Various systems from various manufacturers were tried, and the final choice was the Philips BV Pulsera.

### The BV Pulsera

The BV Pulsera (Figure 2) is a mobile C-arm fluoroscopy system specifically designed for interventional procedures. It was installed in February 2005, and has now been in use for about six months. The principal requirement was for a system that does not overheat, and provides very high quality, good resolution images.

The BV Pulsera fully meets the requirements, yielding clear images of moving structures, including the angioplasty guide wires, as well as providing the long fluoroscopy times sometimes needed for biventricular implantation. The high image quality is maintained even in patients with a very thick chest wall, which used to be a major problem.

The long fluoroscopy times are achieved by a combination of a high-output rotating-anode tube with anatomical programs that have been developed especially for the long and complex electrophysiological procedures (Table 1, Figure 3). In practice, the heat management is so efficient that the tube temperature is never the limiting factor, so that the procedure can always be extended if necessary.

The BV Pulsera offers a choice of low-dose and very-low-dose operation, and a choice of 25 or 12.5 frames per second. The lower frame rate gives a further dose reduction and is more than adequate for most procedures. The low dose is an important factor because of the long fluoroscopy times, and also because the cardiologist stands very close to the image intensifier during the implantation procedure.

▲ Figure 2. The dedicated pacing laboratory with the Philips BV Pulsera mobile C-arm system.

► **The BV Pulsera provides clear images of moving structures, as well as long fluoroscopy times.**

## Cardiac

- 24 ms  $\rightarrow$  24/40 x 12 mA = 7.2 mA per frame (average)
- 12.5 frames/second results in 3.6 mA / second (average)

$$\frac{110 \text{ kV} \times 3.6 \text{ mA}}{2} = 198 \text{ W}$$

(based on 50% duty cycle)

Warm after 60 minutes  
Hot after 70 minutes  
Overheated after 85 minutes

## EP 17-10

- 16.6 ms  $\rightarrow$  16.6/40 x 12 mA = 5 mA per frame (average)
- 12.5 frames/second results in 2.5 mA / second (average)

$$\frac{110 \text{ kV} \times 2.5 \text{ mA}}{2} = 138 \text{ W}$$

(based on 50% duty cycle)

Warm after 100 minutes  
Hot after 120 minutes  
Overheated after 140 minutes

## EP 10-10

- 10 ms  $\rightarrow$  10/40 x 12 mA = 3 mA per frame (average)
- 12.5 frames/second results in 1.5 mA / second (average)

$$\frac{110 \text{ kV} \times 1.5 \text{ mA}}{2} = 83 \text{ W}$$

(based on 50% duty cycle)

**Steady State at 44 °C !**

▲  
Table 1. Heat management using anatomical programs with the BV Pulsera. The following assumptions have been made:

- pulsed fluoroscopy uses a 12 mA curve
- one frame is 40 ms
- continuous fluoroscopy is at 25 frames/second.

The other major advantage of the BV Pulsera over the previous equipment is the ability to record images and play them back instantly, and send them to the Philips Inturis archive, so that they are all available on line for viewing at a later date. The BV Pulsera is used with a Philips ViewForum workstation, which also allows coronary angiograms from the cath lab systems to be retrieved and played back in the operating room. It is very useful if the cardiologist can see the position and morphology of the coronary sinus on an angiogram before starting the implantation procedure. This is a major advantage over an older system which might not be compatible with our cath lab system.

The dynamic images available on the ViewForum can be speeded up, slowed down, zoomed in and zoomed out to provide the best view of the coronary sinus, and the contrast and brightness can be adjusted for optimum perceptibility.

The ViewForum is also prepared for connection to a PACS, which is expected to be installed next year. This will make it possible to display chest X-rays on the ViewForum as well, providing a really comprehensive workstation for pacemaker implantation.

The images are displayed on flat-screen monitors, mounted on a swinging arm that allows them to be swung round for optimum viewing during the procedure. This is an additional important advantage of the BV Pulsera system, as it allows the monitors to be placed in the optimum viewing position when the room is crowded with people and equipment.

Another advantage of using a mobile rather than a fixed facility is that it can be used with a surgical table. It is quite important to use a Trendelenburg tilt at the start of the procedure. This helps to fill up the veins, so that it easier to get the needles into the veins and to insert the initial guide wires. Even when the table is tilted down to the Trendelenburg position the image intensifier can still be brought very close to the patient. This gives more versatility in the projections around the patient, the choice of working height and, in fact, the whole geometry.

The principal application of the BV Pulsera in the Cardiothoracic Centre is in biventricular pacemaker insertion, but it is so versatile that it could replace a cath lab system for coronary angiography or angioplasty in an emergency, or even be used for electrophysiology studies. The BV Pulsera will also be used for research purposes, such as limited coronary care studies, and because it is provided with vascular programs it has already been used to perform aortic stenting. It has full vascular-abdominal-peripheral-cerebrovascular functionality and, if occasion arose, it could even be used as a urology machine or an orthopedic machine.

The decision to acquire the BV Pulsera was partly motivated by the Cardiothoracic Centre's positive experience of Philips in terms of performance and service. Currently all of the fixed installation catheter laboratories and the new CT scanning facilities are Philips products. Nevertheless, any new acquisition is always preceded by a thorough evaluation of the market place, and the BV Pulsera came out well ahead of its competitors.

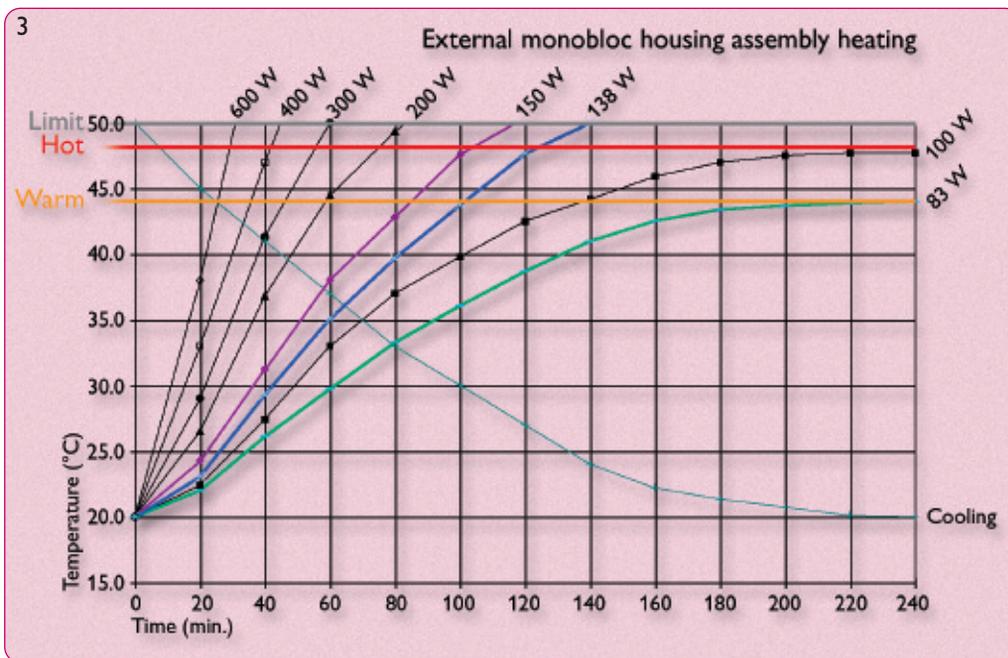


Figure 3. Cooling curves with Cardiac and Electrophysiology anatomical programs (cf. Table 1) assuming pulsed fluoroscopy with a 12 mA curve. Purple: Cardiac. Blue: EP 17-10. Green: EP 10-10.

### The dedicated operating room

From past experience, it was found that there were major advantages in performing pacemaker implantation in a surgical environment using a mobile X-ray system. In Britain and much of continental Europe, pacing and electrophysiological procedures tend to compete with coronary work for cath lab space. This has the potential to create a conflict of interests because pacing and electrophysiology can be quite prolonged procedures on a time-per-unit-case basis. In Britain there is added pressure from government-imposed waiting list targets, which means that the department has to maximize production.

Patients may present with bradycardia, defective pacemakers and tachycardia. The latter may need either radio-frequency ablation or ICD implantation. An increasing proportion of the workload is now biventricular pacing and biventricular ICDs. Catheter ablation is performed in a cath lab, but pacing procedures are best performed in a surgical suite with a mobile fluoroscopy capability, because the major concern with implanting hardware into patients is infection. It is easier to maintain sterility in a dedicated surgical unit than in a standard cath lab.

Moving pacing and electrophysiological activities to a more surgical environment offers several benefits. One simple advantage is that it creates a modicum of excess capacity, which can be useful. However, there are also advantages in terms of the set up of the lab, the high standard of sterility, and the ability to have a dedicated staff who are familiar with the implantation of surgical devices, all of which can have clinical

advantages. The mobile X-ray facility also makes it possible to maximize the use of the pre-existing operative space.

The dedicated operating room has been equipped in accordance with the guidelines published by the British Pacing Electrophysiology Group/Heart Rhythm UK. These state that the ideal facility for pacemaker implantation is an operating room or dedicated pacing laboratory in which the highest standards of sterility can be maintained. While it is possible to implant pacemakers in cardiac cath labs or even in a general radiography department, it is unlikely that operating room standards can be maintained in such areas, which should therefore be regarded as sub-optimal for pacing.

The advantages of a dedicated operating room with a mobile C-arm fluoroscopy system include sterile air and environment quality, flexibility of access, and closer access for cardiological staff. When performing explantations of infected devices it is necessary to have anesthetic support, and to have a consultant cardioplastic surgeon on standby in case of damage to the subclavian vein, atrium or ventricle. For this reason, explantation is always done in the operating room with full surgical support. There is just under 1% mortality from laser extraction, so surgeons sometimes have to react very quickly, which is another reason for having a mobile C-arm that can simply be parked aside.

The Cardiothoracic Centre also has what is probably the UK's largest epicardial pacing program. In these cases it is sometimes important to have an image available of a right ventricular

► **Pacemaker implantation is best performed in a surgical environment.**

► **A surgical suite with a mobile C-arm system offers sterility and flexibility.**

lead or right atrium lead when the chest is open for applying the left ventricular lead directly onto the epicardial surface. Here again, it is very useful to have a mobile X-ray system in the operating room. The dedicated pacing operating room is busy from 9 a.m. to 5 p.m. at least 5 days a week, and often for much longer and during weekends as well.

► **Biventricular pacing is not for a slow heart rate, but to improve heart function.**

Having a separate pacing room keeps the cath labs free, so that pacing does not interfere with interventional cardiology, apart for the demand for radiology staff or nurses. There can be a competition for qualified staff later on in the afternoon when there are emergencies running on in either the cath lab or the pacing room.

In fact, the only time a pacing procedure might be performed in a cath lab is if there is an extraction to do for a femoral vein, when a pacing lead is fractured and is floating free in the heart, but even this sort of procedure can be carried out with the BV Pulsera.

Until recently, the requirements for the mobile fluoroscopy system were not very demanding. Nowadays, with biventricular pacing, it is necessary to follow the passage of the guide wires, catheters and pacing leads. The BV Pulsera provides good-quality images with the full range of views - LAO, RAO and cranio-caudal tilt - with a lower dose than a biplane cath lab system. In addition, it offers a more comfortable working procedure. For example, with the cath lab image intensifier in the LAO position it is difficult to access the left shoulder area where the implantation takes place, while the BV Pulsera can simply be moved aside.

An additional advantage of the BV Pulsera is the movable monitors on the top, so that when the room is crowded with people and equipment the monitors can be placed in the optimum viewing position.

The Cardiothoracic Centre does about 1200 implants a year. As the BV Pulsera has been in use for six months, this means that it will have been used for some 600 procedures, of which 75 will be biventricular pacing, 80 will be ICD's, and about 20 will be extractions, some of which will have used laser equipment.

### **Biventricular pacing**

In conventional pacing for bradycardia, the pacing is applied to the right atrium, if possible, and to the right ventricle. If the patient's own heart rate slows down, the pacemaker will take over as a back up and help the patient with resynchronization pacing. In biventricular

pacing, both the left and the right ventricle are resynchronized, providing better cardiac output and stroke volume.

Biventricular pacing is usually applied in patients with very poor ejection fractions of less than 30%, and the heart must be paced 100% of the time to provide symptomatic benefit. These patients do not need pacing for bradycardia: biventricular pacing is not for a slow heart rate, but to improve heart function.

The principle of biventricular pacing is that both sides of the heart should work together, ejecting blood efficiently into the lungs and all round the body. In some patients there is a conduction block to the left side of the heart, so that if the impulse comes down the septum it goes preferentially to the right-hand side, so that the right side contracts slightly before the left.

Thus, instead of both ventricles being synchronous, there is dissynchrony, so that the movement of the right ventricle will cause the wall of the left ventricle to move outwards when it is supposed to be contracting.

In biventricular pacemaking a second pacing lead is passed into the right atrium and through the coronary sinus into the back of the left ventricle, so that both ventricles are paced together. This improves left ventricular function, ejection fraction and stroke volume. It also reduces the size of the ventricle, the end-diastolic dimensions and pre-systolic mitral regurgitation. Because of the improved cardiac output patients have improved quality of life, improved exercise capacity, and improved mortality.

Sometimes it is not possible to gain access to the coronary sinus with the catheter. In such cases the chest is opened and the lead is applied directly to the epicardium. This, of course, requires full operating room conditions.

The need to have 100% pacing makes it even more important to have good threshold values that ensure the longevity of the device, so correct placement of the LV lead is critical. A very lateral position is needed to achieve maximum resynchronization, and it must not be too close to the RV lead. This means that the branches of the coronary sinus have to be chosen very carefully and also, of course, in the light of the patient's own anatomy. This varies considerably, and there are some patients who only have one large coronary sinus with no branches.

There are no specific landmarks for placing the LV lead, but it should be a distal and as lateral

► **The BV Pulsera provides good-quality images with the full range of views.**

► **Correct placement of the left ventricular lead is critical.**

as possible to achieve the maximum resynchronization effect.

The imaging system plays a vital role. The image quality has to be sufficient to show as much of the vascular structure as possible, and the fluoroscopy system must run as long as necessary to achieve correct placement. In the past it was sometimes difficult to maneuver the guide wire into the vein, and then the fluoroscopy system would overheat at the critical moment. Fortunately, the BV Pulsera has improved the situation immensely.

### Lead placement

Even with a high-quality imaging system, placement of the LV lead still requires a certain amount of skill. Just finding the coronary sinus can be difficult in some patients, and then the guide wire has to be maneuvered into a minute side branch of it. All this has to be done at a significant distance from the lead, so the technique depends on torquing the guide wires. Then there is a vast selection of differently shaped catheters and hooks and guide wires to provide more support, more torque, or whatever may be needed to get access to the coronary sinus, and then to pass the lead up the coronary sinus and into one of the lateral veins.

There is a selection of differently shaped catheters with long or short hooks for access to the coronary sinus. Then there are differently shaped guide wires that pass through these and, once these are positioned the vessel, the coronary sinus lead is placed over the wire and positioned in the vessel. Some leads have a pigtail that springs out and holds the lead in position, rather like a stent.

After the leads have been implanted under fluoroscopy, the position is checked by a cardiac physiologist. Accurate placement is critical if the biventricular pacing is going to provide significant benefit to the patient for a reasonable length of time. The voltage needed to pace the heart varies considerably, depending on the position, and high values mean that the device will only last for about eighteen months or two years.

Optimum placement is determined by the electrical function rather than the position of the lead in the vein. It may be necessary to retract the lead slightly to achieve a good electrical function rather than to try and position it a third of the way down or two-thirds of the way.

Consequently, it is important to have a live image, and to be able to have the electrical readout at the same time.

Ideally, the threshold voltage for pacing the heart would be less than 1 V. This is sometimes achieved with coronary sinus leads, but the voltage is often significantly higher. There is nowhere to tether the lead to in the coronary sinus, because it is a continuous smooth structure, so the aim is to position the lead in a nice branch of the coronary sinus with a threshold value that is appropriate to the longevity of the device.

There is considerable variation in the anatomy of the coronary sinus, so it is necessary to make a coronary sinus venogram showing all the side branches, in order to select a suitable side branch for placement of the lead.

### Results

When successful, the results of biventricular pacing are astonishing. Some patients report a 700% increase in what they can do. On the other hand, some 20% to 25% of patients are non-responders. There is a great deal of current research into why some patients fail to respond to the therapy. There is obviously something different in their physiology or presentation that they do not respond. But the results of people coming through clinic are amazing.

#### Case 1.

An elderly patient with end stage heart failure was referred for resynchronization pacing. The resynchronization lead was successfully introduced into the coronary sinus, but could not be passed through into the posterolateral vein, due to the narrow lumen of the vessel. The lead was left in a stable position in the coronary sinus, and provided good biventricular pacing with significant symptomatic improvement. The first run (Figure 4a) shows the balloon being inflated with injection of contrast into the coronary sinus. The anterior cardiac vein is clearly shown, together with lighter filling of the middle cardiac vein. However, there is no filling of the posterolateral vein, because the entrance is blocked by the distal position of the balloon. In the second run (Figure 4b) the balloon has been pulled back to a more proximal position in the coronary sinus. Following inflation there is filling of the posterolateral vein and the middle cardiac vein is also shown. The third run (Figure 4c) is a coronary sinus angiogram showing the middle cardiac vein passing along the inferior border of the heart.

#### Case 2.

A 91 year old female patient presented with end stage heart failure in MIHA 3-4 classification. Even with maximum medication she remained very symptomatic, with a left bundle branch block

► **The imaging system must combine high image quality with lengthy runs.**

► **When successful, the results of biventricular pacemaking are astonishing.**

► **Accurate placement is critical for providing significant benefit for a reasonable period.**

Figure 4a. The first run shows the balloon being inflated with injection of contrast into the coronary sinus. The anterior cardiac vein is clearly shown, together with the middle cardiac vein. There is no filling of the posterolateral vein, because the entrance is blocked by the distal position of the balloon.

Figure 4b. The second run (RAO) shows the balloon pulled back to a more proximal position in the coronary sinus. Following inflation there is filling of a small posterolateral vein.

Figure 4c. The third run shows the middle cardiac vein passing along the inferior border of the heart. A branch extends up to the lateral border. This was used for lead positioning

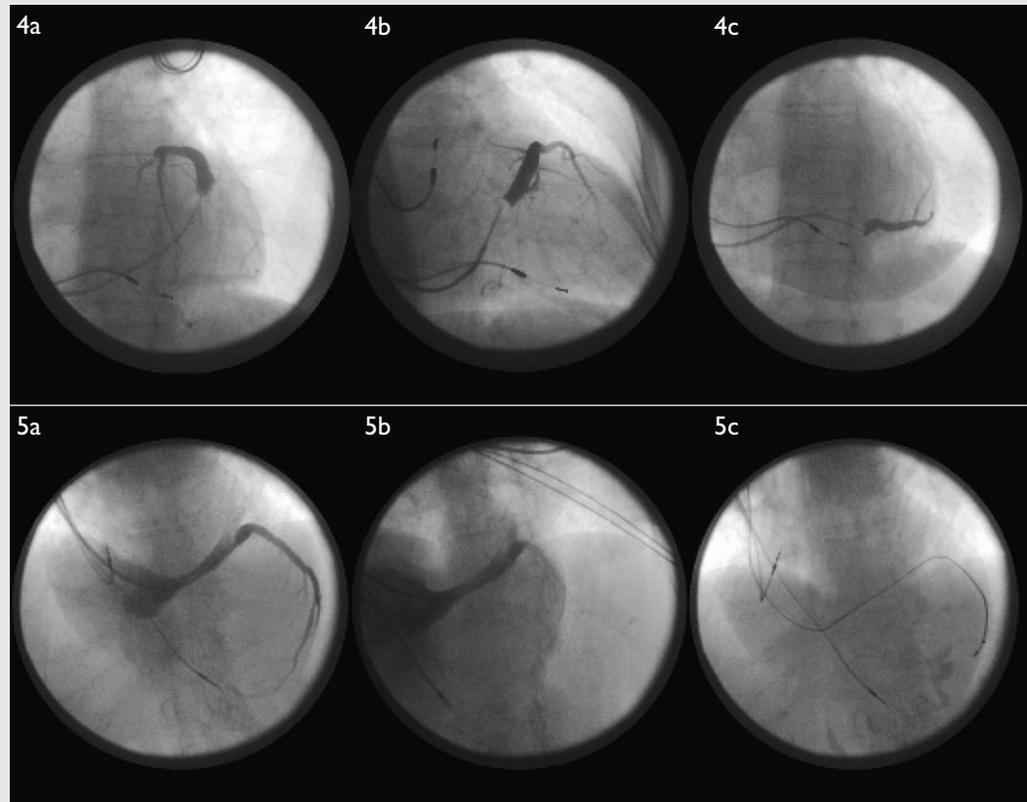


Figure 4. Positioning of a resynchronization lead in the coronary sinus. The lead could not be passed through into the posterolateral vein, due to the narrow lumen of the vessel.

Figure 5. Implantation of a biventricular pacemaker in a 91 year old female patient with end stage heart failure.

Figure 5a. Coronary sinus angiogram. The right ventricular apical lead is already in position. The catheter has sub-selected the lateral/posterolateral branch of the coronary sinus. Even this PA view shows the required position of the lead very clearly.

Figure 5b. LAO view showing that the vessel extends to the lateral border of the heart. It was decided to implant the coronary sinus directly via this vessel.

Figure 5c. Final position with the LV lead in a stable position on the lateral wall of the left ventricle.

and an enlarged heart. It was therefore decided to implant a biventricular pacemaker. The coronary sinus angiogram (Figure 5a) shows a right ventricular apical lead already in position. The catheter has sub-selected the lateral/posterolateral branch of the coronary sinus. Even in this PA view it shows the required position of the lead very clearly. The LAO view (Figure 5b) shows that the lead travels very nicely to the lateral border of the heart, so it was decided to implant the coronary sinus directly via this vessel. The last image (Figure 5c) shows the final position, with the coronary sinus or LV lead in a stable position on the lateral wall of the left

ventricle. This provided good biventricular pacing and the patient has made a significant symptomatic improvement.

#### Case 3.

An elderly female patient presented with atrial fibrillation and end stage left ventricular failure in very breathless MHIA 3 classification despite maximum therapy. It was decided to implant a biventricular pacemaker to improve her symptoms and prognosis.

On the first attempt to implant the system both the guide wires that went to the left side, which

Figure 6. biventricular pacemaker implantation in a patient with a left sided subclavian vein. It was difficult to implant the right ventricular lead, whereas the left ventricular lead was relatively easy.

Figure 6a. The right ventricular lead in a very unusual position through the tricuspid valve, with the catheter directly in the coronary sinus.

Figure 6b. The right ventricular lead in the right ventricle, with a guide wire in the subclavian vein running directly into the coronary sinus, and a catheter from the subclavian vein into the coronary sinus.

Figure 6c. The catheter selectively engages the lateral branch of the coronary sinus, with a guide wire passed down through the lateral branch.

Figure 6d. Advancing the catheter over the guide wire permitted identification of a more distal bifurcation.

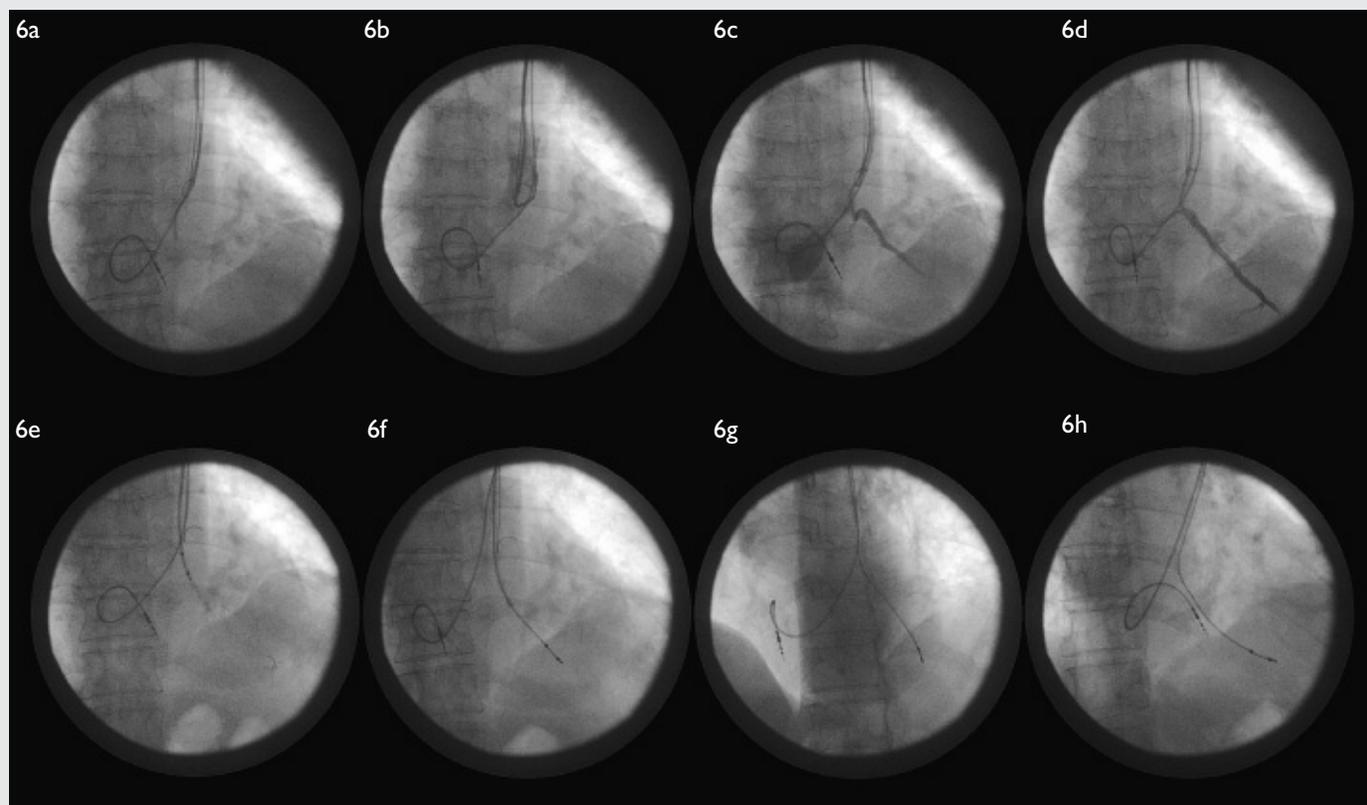


Figure 6e. The lead is advanced through the guide catheter into the branch of the lateral branch of the coronary sinus.

Figure 6f. The coronary sinus lead in position in the lateral branch.

Figure 6g. The same situation as Figure 6f in LAO projection going to the lateral border of the heart.

Figure 6h. The same situation as Figure 6f in RAO projection showing the difference between the positions of the right and the left ventricular leads.

is very unusual, because one normally goes to the right side. We assumed that we had either cannulated the arterial system by mistake, or we had an usual anatomical abnormality known as a leftsided subclavian vein. This often drains directly into the coronary sinus, which is the vessel needed for the left ventricular lead. As a result, it was very difficult to implanting the right ventricular lead, and the procedure took several hours, whereas the left ventricular lead which is normally technically difficult was very easy, as the access from the catheter went straight into a branch on the lateral border of the heart, from the coronary sinus, and the left

ventricular lead implant in this case took a matter of minutes.

Leftsided clavian veins probably occur in about 1 in 500 patients.

Figure 6a shows the right ventricular lead in a very unusual position through the tricuspid valve, with the catheter directly in the coronary sinus. Figure 6b shows the lead in the right ventricle again, with a guide wire in the subclavian vein running directly into the coronary sinus, and a catheter from the subclavian vein into the coronary sinus with an injection of contrast

illustrating the direct drainage of the coronary sinus into the right atrium with the subclavian vein draining through the coronary sinus. There is a guide wire extending out of the end of the catheter, while contrast is being injected through the catheter to protect the coronary sinus against dissection. The catheter is then passed down through the coronary sinus perfect. Figure 6c shows the catheter selectively engaging the lateral branch of the coronary sinus, which is the ideal vessel for implantation of a left ventricular lead.

The guide wire is then passed down through the lateral branch. Figure 6d shows the guide wire tip and the anatomy of the coronary sinus, including a more distal bifurcation. Figure 6e shows the guide catheter being advanced over the guide wire down into the lateral branch of the coronary sinus. Because the tip of the pacing lead would not pass through the end of the catheter, the catheter had to “pipe cleaned” with a smaller lead, after which the pacing lead was re-inserted.

Figure 6f shows the coronary sinus lead in the lateral branch of the coronary sinus pacing the left ventricle. Figure 6g shows the same situation in LAO projection going to the lateral border of the heart, and Figure 6h is the RAO view showing the difference between the positions of the right and the left ventricular leads.

#### **Safety considerations**

Radiation dose and the quantity of contrast agent injected are important safety considerations in any lengthy vascular procedure. The high image quality of the BV Pulsera system, together with pulsed imaging, mean that both the radiation exposure per procedure and the amount of contrast agent required are significantly less than with the previous system. The latter point is very important with seriously ill patients, in view of the risk of contrast-induced necrotoxicity.

The improved image quality reduces the number of shots needed. The initial angiogram might take two injections of 10 ml, while the three AP, RAO and LAO shots needed for orientation will

be another three injections of about 8 ml each, but the major saving is in the amount of contrast agent needed to image the coronary sinus. With the improved fluoro it is no longer necessary to feel one’s way with regular contrast injections.

The excellent heat management also contributes to radiation safety, as it is no longer necessary to stop the procedure for cooling off. Previously, when a case had to be abandoned, there was quite a significant radiation time involved in just setting up again. That meant that a patient not only had to be subjected to the radiation exposure for the rest of the case, but there was an extra 15 minutes of radiation needed just to get back to the point where the procedure was interrupted.

In addition to the dose-saving pulsed imaging technique, the BV Pulsera has several built-in radiation safety features. New beam filters reduce the patient skin dose by 40% as compared with conventional filters, and the lead shutters can be rotated and moved independently of each other to provide protection against direct radiation and reduce scatter radiation. A laser aiming device allows the C-arm to be positioned without applying radiation, and shutters and image orientation can be adjusted on Last Image Hold without radiation.

Radiation safety is particularly important in biventricular pacing because more oblique views are used, rather than the standard AP screening, and that is something that if I were doing large amounts of biventricular pacing. All staff are encouraged to monitor their own radiation safety procedures and adopt safe working practices.

The BV Pulsera system also provides real-time feedback on the actual dose usage and the effects of collimation and field-of-view on dose. This allows the user to take appropriate measures to adjust the amount of dose. The system produces a quantitative dose report after exams for recordkeeping ■

► **The excellent heat management makes it unnecessary to stop and re-start the procedure.**

► **High image quality reduces radiation and the amount of contrast agent.**