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FRAGILE LIVES

Written by Stephen Westaby

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fragile lives

A heart surgeon's stories of life and death on the operating table

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the black banana

'We shall never surrender'

Winston Churchill, during the
Battle of Britain, 1940

Monday 15 February 1999, 3.45 am. No one calls with good news at night. I'd been in Australia for just thirteen hours after a twenty-hour flight. In pitch darkness I scrambled across my hotel bed and knocked the receiver to the floor. The call was lost. I swiftly slipped back into sleep, courtesy of melatonin tablets and the bottle of Merlot I'd drunk at dinner. Ten minutes later the phone rang again. This time I fielded it successfully, but I was irritated.

'Westaby? This is Archer. Where are you?'

'Nick, you know I'm damned well in Australia. It's the middle of the fucking night – what's the problem?'

I didn't want to hear the answer.

'Steve, I'm sorry, but we need you to come back. We have a sick baby with ALCAPA. The parents know you and want you to do the surgery.'

Oh joy.

'When?'

'As soon as possible. She has bad heart failure and is as good as we can make her. The ventricle is poor.'

Already there was no point in further discussion. I pictured the frantic parents, desperate for an operation before it was too late, and the four grandparents huddled around the cot trying to lend support but only transmitting anxiety. I really had no other choice.

'OK, I'll fly back today. You tell the team we'll do it tomorrow, whenever that is.'

It was high summer in the southern hemisphere and early-morning light had just begun to penetrate the drapes. Further attempts to sleep were pointless. I stepped through the curtains onto the balcony and gazed out at arguably the finest city vista in the world. Across the harbour the first hint of sunrise cast ghostly shadows over the Opera House. Flags fluttered on masts in the harbour below, and to my right the tall, white city lights stood out against the pink morning sky. The peace was broken by the shifting gears of a Harley-Davidson. Maybe a surgeon racing into Sydney.

In Oxford a real-life tragedy was unfolding for this little family. Kirsty was a beautiful six-month-old baby girl in whom fate had installed a lethal self-destruct mechanism, a miserable detail that seemed destined to end her life before her first birthday. ALCAPA is an abbreviation for Anomalous Left Coronary Artery from the Pulmonary Artery, an isolated and exceptionally rare

congenital anomaly in the overall complexity of human anatomy.

Simply put, it's bad wiring. Both coronary arteries should rise out of the aorta and supply the heart muscle with well-oxygenated blood under high pressure. They should never be attached to the pulmonary artery, as this has both low pressure and poor oxygen content. Early survival with ALCAPA therefore depends on the development of new 'collateral' blood vessels between the normal right coronary artery and the misplaced left coronary artery. But these eventually are insufficient to sustain blood flow to the main pumping chamber. Muscle cells deprived of oxygen die and are replaced by scar tissue, leaving baby to suffer what are in effect repeated, painful heart attacks. Scar tissue stretches, causing the left ventricle to dilate, then the heart progressively fails and the lungs become congested with blood, leading to breathlessness and exhaustion. Even during feeding.

So by six months of age Kirsty already had the same problem as my grandfather – heart failure through end stage coronary heart disease. But because ALCAPA is exceedingly rare, the diagnosis is seldom made until the infant is terminally ill. Fortunately, her parents were intelligent, had recognised that there was a serious problem and were persistent in finding help for her.

Kirsty's story was particularly harrowing. Her mother Becky already had a three-year-old son and was an experienced and responsible mum. She'd contracted no illnesses, smoked no cigarettes or drunk any alcohol during pregnancy, risking nothing that could potentially

harm the foetus inside her. All antenatal checks and ultrasound scans appeared normal. Kirsty was born on 21 August 1998 by elective Caesarean section with a spinal anaesthetic and at first everything seemed normal. But not for long.

In the womb the pressures and oxygen content of the aorta and pulmonary artery are the same, so Kirsty's tiny heart was safe. After birth the circulations to the body and newly expanded lungs separate, and both pressure and oxygen content in the pulmonary artery fall. So, in cases of ALCAPA, both blood flow and oxygen content in that critically important left coronary artery fall precipitously, too. Kirsty was grunting even during the first attempt to breastfeed in the hospital, and Becky noticed beads of sweat trickling from the bridge of her baby's nose. The effort of feeding repeatedly made her fractious and distressed.

This was distinctly different from how her son had been, so Becky asked for a paediatrician to review Kirsty. She was told that there was absolutely nothing to worry about. This is exactly what anxious parents want to hear, but the truth was that no one had bothered to find out what was wrong. It was too much trouble – piss-poor medicine. At this stage Becky had little choice but to take her irritable but precious little bundle home.

Within weeks Becky was certain that something was seriously amiss, because during every feed there was sweating and vomiting. Kirsty struggled for breath, clenched her little fists and screamed until she was puce in the face. Together they made many visits to the GP, some-

times as many as three times a week, but they always received the same non-committal reassurance – tense, unpleasant encounters, as Becky was deemed neurotic and unable to cope.

But despite Kirsty's rapid breathing she had no temperature. Chest infections were ruled out, and her belly was soft, with no signs of stomach or intestinal blockage. All of the common paediatric problems were excluded. Family and friends offered rational explanations – it must be colic and would get better. But with her husband working abroad Becky became more and more anxious. Kirsty wasn't gaining weight. She had a pasty, washed-out look and a cough like a dog's bark.

In reality this baby was suffering repeated small heart attacks with excruciating chest pain that she could neither communicate nor understand. The human body can be outlandishly cruel.

Eventually, after a meltdown in the GP's surgery, Becky insisted that Kirsty should be referred to the local hospital. Twice she had chest X-rays, only to be diagnosed with bronchiolitis – inflamed breathing tubes – on both occasions. Then one day during her afternoon nap Kirsty turned a terrible slate-grey colour. She was barely rousable and limp. In abject panic Becky snatched her up and rushed to the surgery. But by the time they presented themselves at the receptionist the baby was awake and pink again. There followed yet another put-down. Becky was told to stop fussing and that there were children to be seen who were actually sick. On this occasion mother and child were acrimoniously dispatched, once more with a

prescription for antibiotics. Kirsty's enormous heart remained undetected.

Becky's anxiety and frustration now turned to desperation. Every instinct told her that if she didn't push further something dreadful was going to happen, so she drove directly to the accident and emergency department of her small local hospital. They were seen by a sympathetic female doctor who had children of her own. Recognising that a mother's instinct was usually correct, she referred them on to a larger city hospital for review by the on-call paediatrician.

It was a bitterly cold, frosty night and they were left sitting in an unheated hospital corridor for several hours. Becky frantically struggled to keep Kirsty warm but she became progressively more limp and grey. Eventually, late into the night, they were seen. The first junior doctor suggested bronchiolitis and intended to dismiss them without investigation. Bronchiolitis seemed to be the only paediatric diagnosis these doctors had heard of. Becky was angry and frustrated, yet afraid that she would be thrown out if she protested.

When she refused to leave without a chest X-ray she was told off for her unreasonable attitude – how thoughtless to inconvenience the hard-pressed duty radiographer at that time of night. So the sad pair were dispatched unescorted down poorly lit corridors and icy outside walkways to find their own way to the X-ray department. It was well past midnight when they returned, clutching the tell-tale picture, which Becky presented to a nurse. They were parked once more.

Another thirty minutes passed, then a dramatic shift in attitude from the hospital staff. Kirsty and Becky were ushered into a cubicle with different doctors. Now there were hushed voices, grave expressions, and nurses bringing drips and drugs. This was even more frightening than them being ignored. The previously mean, now embarrassed nurse took Becky aside to explain that Kirsty was being transferred to the specialist children's heart unit in Oxford. By ambulance this time. Suddenly she was too sick to remain unsupervised.

So what did the X-ray show to trigger this frenzy of activity? Kirsty had a massive heart. No one before then had bothered to examine her, but her problem was immediately obvious on the X-ray film. When the staff were pressed about her previous X-rays at the same hospital, Becky was told that the heart shadow had been misinterpreted as fluid – 'Sorry, but it's an easy mistake to make.' Some mistake! How do you begin to describe a mother's anxiety that hits like an axe, drains blood from the throat and takes your legs away?

Things were different when they arrived in Oxford. The paediatric cardiology registrar met the ambulance and took them directly to a ward packed with children with serious heart problems and beeping monitors – a hive of activity in the depths of night.

Nick Archer arrived at 3 am. On examining Kirsty he was immediately concerned by her body temperature. Despite Becky's best efforts she was cold and needed to be in an incubator. An ECG and blood tests were done quickly, then the echo machine was brought in to image

Kirsty's heart chambers. First it seemed like good news. All four chambers were there, with no holes between them. But worryingly the left atrium and ventricle were both enlarged, the ventricle dramatically so. This explained the heart failure and accounted for the striking chest X-ray.

In little more than an hour the cardiology team established that Kirsty had severe heart failure from multiple heart attacks. Parts of the left ventricular wall now consisted of thin scar tissue interspersed with poorly contracting muscle, a rare condition in an infant but one that provided the likely diagnosis. One further test was needed. A cardiac catheter would confirm the diagnosis but would require a general anaesthetic, so she'd have to be in much better condition before proceeding.

By now, waiting in the hospital, Becky was bereft with grief, physically and emotionally drained. Her husband was away in the States on business and she felt very much alone. Guilt and irrational thoughts preoccupied her. Had she exercised too much during pregnancy? Drunk too much coffee? Offended God? There has to be a reason for everything. Deep despair took a grip, and her anxiety soon progressed to outright panic. She was certain she'd lose Kirsty. But as the winter sun crested the horizon she lost consciousness for a couple of hours. When she awoke the ward was busy, full of positive, warm-hearted people who tried to reassure her that, even though things were difficult, there was a great team caring for Kirsty.

It was a full five weeks before Kirsty was considered fit enough for the cardiac catheter. Becky had her husband

back to share the pain, and the evening before the operation the anaesthetist came round to talk. Normally a jolly and optimistic character, on this occasion he didn't have much to smile about. He warned the family that Kirsty's heart was so severely damaged that they might lose her during the procedure. It was only fair to inform them of this. So that night Kirsty was christened in her cot by the hospital chaplain, the doctors, nurses and other families gathering around the bed to support them.

Everyone knew what the catheter would show. There was only one rare condition that did this to a baby, that caused multiple heart attacks in the first few months of life – ALCAPA. Becky overhead the words 'early surgery' and hoped that they didn't mean a transplant. Both she and her husband stayed by the cot the whole night long, terrified that Kirsty might slip away. In the morning, without having slept and paralysed by fear, Becky dressed her baby in her best pyjamas and tied a bow in her hair for her trip to the catheterisation laboratory. Ironically it was Valentine's Day. As Becky put it to me later, 'A girl has to look her best, even when she's poorly.'

Once I was on the plane home I started to sketch the anatomy of Kirsty's aorta, pulmonary artery and abnormal left coronary artery. I knew that the current techniques in operations for ALCAPA had limitations and a substantial failure rate, so I used my time during the flight plane to work out an alternative. By the time we were cruising high above Java I'd designed my new operation. Last on, I was first off the plane back in London. As I waited for the airbridge to connect and the doors to open,

the cabin services director handed me a bottle of champagne, wished me luck and whispered, 'You operated on my sister's baby.' Small world. I thanked her.

I called my colleague Katsumata when I got back to Oxford and asked him to bring Kirsty's parents to my office with a consent form. The cardiac catheter had shown precisely what Archer had suspected. Kirsty needed surgery as soon as possible.

Becky looked tired and drawn when I saw her. She knew instinctively who I was. Her face lit up as they entered my office in a cold Portakabin.

'We're so pleased to see you,' she said. 'How was the trip?'

'Good. Very restful,' I lied. 'We need to get on with this, don't we?'

Katsumata had managed to find an electric convection heater to take the chill from the room, and we all set about breaking the ice. They explained that a family member was a representative for a heart valve company and knew me well. He'd been expecting to see me at the meeting in Australia. They were sorry about my aborted trip but profoundly grateful that I'd come back as they wouldn't let anyone else operate on their little girl. Despite the warmth, Becky was now trembling uncontrollably with abject fear. Poor kid. Finally, after weeks in hospital the time had come – the day she might lose her baby.

I don't do transmitted anxiety if I can help it. But it's much more difficult for my anaesthetist colleagues who have to deal with the agonising separation when the patient is given over to them. I described my planned

operation to the team and explained why I felt it would be an improvement on existing techniques. The new left coronary artery would be constructed with a flap of aortic wall that would sit below a corresponding pulmonary flap to make a tube, the latter containing the misplaced origin of the left coronary artery at its apex. The product would be a new coronary artery delivering high-pressure, well-oxygenated blood directly from the aorta, where it should have come from in the first place. Blood fully saturated with oxygen would then supply the failing heart muscle and prevent further heart attacks. Katsumata was intrigued and excited by my proposed approach, so much so that he rushed off to call the hospital's film crew.

With severe heart failure, the risks of the operation were substantial. Becky's shaky hand signed the consent form and I walked back with them to the children's ward. When we reached the cot Kirsty's heart failure was worse than I imagined, indeed the worst I'd ever seen in any child. She was emaciated, with virtually no body fat, her heaving ribs and rapid breathing a consequence of her congested lungs, and her abdomen swollen with fluid. She was still a pretty baby, but without immediate surgery she'd be dead within days. Although a voice in my head screamed, 'Oh shit,' my mouth correctly said, 'I'll go to theatre now.'

The anaesthetist and the nurses were busily preparing drugs and catheters in the anaesthetic room. He knew the score, having already anaesthetised Kirsty for the cardiac catheterisation, and some of the monitoring lines were still in place.

'Do you really think you can get this baby through?' was his opening line.

I didn't reply, bidding a cheery 'Good morning' to the nurses and perfusion team in the operating theatre, then went straight to the coffee room. I wanted to avoid seeing Becky leave her baby with strangers, always an excruciating event.

When I returned, Kirsty was already on the operating table, covered in green drapes held in place with an adherent plastic drape. All that was visible were her bony little chest and swollen abdomen. Heart surgery needs to be an impersonal, technical exercise.

I joined Katsumata and my six-foot, six-inch Australian colleague Matthew at the scrub sink. While we scrubbed in silence the film camera was carefully positioned next to the operating lights. There was a palpable buzz of excitement. We were about to do something novel, esoteric and risky.

There was no bleeding as I drew the scalpel blade along the skin over Kirsty's breast bone. In shock, her skin capillaries had shut down to divert blood to vital organs. Next the electrocauter cut through the thin layer of fat onto the bone, producing its characteristic buzzing noise accompanied by a whiff of burning as the current cauterised the oozing blood vessels, although this time there were few of these. Then the electric saw cut through the length of her sternum, exposing bright red bone marrow.

We used a small metal retractor to crank open her tiny chest, bending and stretching the joints between the ribs and the spinal column. In babies the fleshy thymus gland

lies between the sternum and the fibrous sac around the heart, but by now it had done its work producing antibodies for the foetus so we removed it.

The electrocauter continued its messy but vital work, cutting through the fibrous pericardial sac to expose the heart, straw-coloured fluid pouring out and being drawn away by the sucker. Meanwhile the other members of the team worked on silently. The anaesthetist gave heparin to stop Kirsty's blood from clotting in the heart–lung machine, the perfusion team set up the complex array of tubing, pumps and oxygenating equipment to keep Kirsty's body alive when her heart was stopped, and the scrub nurse concentrated on having the correct surgical instruments ready to slap into my palm. I rarely had to ask for anything. This complex, highly coordinated work relies heavily on having a steady, consistent team, and as most of them had been with me for years they enjoyed my complete confidence.

As we pulled up the edges of the pericardial membrane to display the heart, Katsumata – in a moment of wry Japanese humour in times of stress – involuntarily uttered what now had become our surgical catchphrase, 'Oh shit, don't mention the war.' Back from his first cigarette, the anaesthetist popped his head over the drapes in response to Katsumata's comment. I agreed that things were even worse than we'd thought. Others could see it all on the video screen.

What should have been a walnut-sized heart was revealed to be the size of a lemon. The enlarged right coronary artery was obvious, its many inflated branches

crossing over towards the left ventricle. While the right side of the heart pumped vigorously against raised pressure in the lungs, the left ventricle was hugely dilated and barely moved. Batches of newly necrotic muscle merged with areas of white, fibrous scar tissue, the result of many small, painful heart attacks endured by Kirsty during her first six months of life. Katsumata was right to be concerned, but I didn't respond to his anxieties. We were committed to rectifying that blood supply and hopefully improving matters. Kirsty had survived to this point and it was our job to keep it that way.

When asked whether I'm ever anxious about operating on hearts I use a standard, evasive reply: 'No, it's not me on the operating table.' But having exposed this heart I began to question the wisdom of attempting such a complex operation having come straight from a day-long flight. Yet what would have been gained by turning her down for surgery or procrastinating further?

For Kirsty there was no alternative. Urgent heart transplants were virtually impossible in babies, so this replumbing of her heart's blood supply was her only chance of life. The Grim Reaper was perching on the video camera and we all knew it, but now I was committed there could be no turning back.

Tiny pipes were inserted to connect her to the heart–lung machine, and I then gave the signal to continue. The perfusion technician turned on the roller pump and Kirsty's heart gradually emptied. At this point technology had taken over, diverting blood away from her lungs and into the synthetic oxygenator. With her empty heart still

beating I cut through the pulmonary artery above the origin of the anomalous coronary, which sat there like the pearl in an oyster. Now we had to connect it without tension to the high-pressure aorta that lay an inch away. The conventional method was simply to trying to stretch and re-implant the origin of the vessel into the side of the aorta. But this could result in thrombosis and blockage, so I pressed on with my new technique.

This delicate exercise could only be achieved by clamping the aorta and temporarily stopping all blood flow to the heart. We'd protect the muscle by infusing cardioplegia fluid directly into both coronary arteries, flushing all the blood out and collapsing the ventricle like a punctured football. This induced state of inactivity, common in heart surgery, is reversed simply by removing the clamp on the aorta, which allows blood from the heart–lung machine to flow back into the coronary arteries.

For the reconstruction of this tiny vessel the stitching had to be precise, accurate and watertight. The procedure went well. Just thirty minutes after the heart was stopped, the conjoined flaps restored Kirsty's coronary artery anatomy to what it should have been. As the clamp was removed, bright red oxygenated blood – rather than deoxygenated blue blood – flooded the left ventricular muscle. Her heart changed from a pale pink colour to deep purple, then became almost black in parts. Before re-constructing the pulmonary artery we checked that there was no bleeding from the lines of stitching behind it. Soon the electrocardiogram showed uncoordinated electrical activity, and the heart stiffened with renewed muscle tone.

Unusually for a child, her reperfused heart kept writhing and squirming in ventricular fibrillation. We used an electric shock directly through the muscle to restore normal rhythm. Ten volts – zap! The heart defibrillated and stopped wriggling. It was now motionless but we expected a normal rhythm to resume at any moment. But it didn't. The purple ball fibrillated and squirmed again, and the anaesthetist's head popped over the drapes to request the obvious – 'Shock it again!' We did and the same thing happened. It wasn't coming back.

This was serious electrical instability caused by the scar tissue, so we gave the appropriate drugs to stabilise the muscle cell membranes.

'Let's give it more reperfusion time,' I told the anaesthetist.

'OK, I'll go out for a fag then,' he said.

Twenty minutes later we tried again. Twenty volts – zap! This time her whole little body levitated from the operating table and her heart defibrillated. Although it slowly began to beat, it was barely more than a flicker. Ominous, but we had drugs in reserve to make it pump harder.

I asked the anaesthetist to start an adrenaline infusion and told the perfusionist to cut back on pump flow to leave some blood in the heart. This was operating theatre protocol, and it's just like the military. You make a request to a medical colleague but give orders to the technical staff. If you start giving orders to an anaesthetist they'll tell you to piss off, and will go off and do something different.

While the anaesthetist and the perfusionist worked together to check and optimise the blood chemistry, my gaze remained fixed on Kirsty's pathetic little heart. The new coronary artery was fine – there was no kink in the tube and no bleeding. For the first time the left ventricle was receiving well-oxygenated blood at the same pressure as the rest of the body. But her heart still looked like an overripe plum and was barely beating at all. Although I heard myself telling the team to give it another half hour's support on the pump, what I was really thinking was we're stuffed, this heart's had it; great operation – dead baby.

Of course, I didn't let the others know my thoughts. They'd salvaged so many catastrophes that they expected me to pull this one off too. But I was starting to fade. I suggested that the cameraman should stop filming for a while because nothing was going to change and asked Katsumata to come to my side of the operating table while I took a break. I removed my gown and gloves, and went to make a call in the anaesthetic room. Mike followed.

'Can you repair it?' he asked me.

'Don't think so.'

'I'll get Archer to warn the parents, then.'

I slumped on a stool and picked up the phone. One of the lovely nurses put a coffee and doughnut in front of me. With her arm around my shoulder, she felt the cold sweat dripping down the nape of my neck.

'I'll get you a dry top,' she said.

In five minutes Archer was down from his outpatient clinic at the theatre door. He didn't need to ask.

‘Thought you might have trouble. Anything I can do?’

‘Take a look at the echo,’ I said. ‘The repair’s fine but the ventricle’s lousy. Mitral valve’s leaking. At this rate we’re not going to get off the pump.’

My bladder was full and I wandered off to the loo. When I got back, my brain had regained control without that distraction and I now really needed to focus. What, if anything, could I do to make things better? I was running out of ideas.

The left ventricle was scarred, dilated and now globular – not the normal elliptical shape. This distortion had pulled open the mitral valve and prevented it from closing. As the left ventricle tried to pump blood around the body as much as half of it flowed backwards to the lungs. Heart function is always temporarily worsened during surgery, but in Kirsty’s case it seemed terminal. I’d hoped that resting the heart on the bypass machine would help it to recover. It hadn’t.

I went back to the operating theatre, scrubbed up again and switched with Katsumata. He said nothing, but looked crestfallen – a clear message. I asked the anaesthetist to start ventilating the lungs and told the perfusionist to prepare to slowly ease off the machine. At this point Kirsty’s heart needed to take over and support the circulation, otherwise she’d die on the operating table. We all stared at the traces on the screen, hoping to see her blood pressure rise. It briefly reached half normal, but then fell away rapidly as the pump was switched off.

‘Shall we go back on?’ asked Katsumata.

Watching the left ventricle flicker on the echo, the perfusionist questioned whether it was worth it. But ‘She’s had it, hasn’t she?’ was the real message from behind the drapes.

I wasn’t yet ready to call it. Failure would mean death for the little girl and a life of torment for the parents

‘Let’s go back on, give it another half hour.’

This in itself was problematic, as a long bypass time always lessened the chance of recovery.

Kirsty’s parents were waiting in the children’s ward – Archer had gone to warn them. When we called him back, Becky insisted on coming to the doors of the operating theatre complex with him. It’s impossible to describe how a mother feels in these circumstances. All I knew was that the prospect of her holding Kirsty’s emaciated and lifeless corpse was not far away. Should I tell her that the heart was too badly damaged, that the diagnosis should have been made months ago and that Kirsty had been let down by an overburdened system?

In her own words, these are the very powerful thoughts that Becky recorded in her diary at the time.

> Dr Archer came to see us at hourly intervals. After around four hours I thought everything had gone well. Kirsty was to be taken off bypass and then transferred to intensive care. I popped down to the canteen to grab a sandwich but as I was making my way back one of the ward nurses was looking for me. She told me I needed to come back upstairs because Dr Archer was waiting to see us. I was really pleased

and asked if the operation was done. Could we please see her? She looked very serious and said we must speak to Dr Archer. Though she was really kind and professional I guessed that something was wrong.

Back in the room a stern faced Dr Archer sat us down. He explained that despite the best efforts of the surgical team, Kirsty's heart would not separate from the bypass machine. The surgeons were still trying but the prospects looked bleak. We may lose her.

Then he had to leave. By now my head was spinning. I remember feeling sort of drunk. This wasn't the plan. If we waited patiently everything would be OK because that sort of thing only happens to other people.

Then Dr Archer came back. He told us he was so sorry. Every option had been exhausted. He would be arranging for us to go and hold her to say goodbye. I could not bear the thought that when I saw her again she would be cold. My baby was so soft and warm. Smelt delicious, hair like velvet, hot fuzzy cheeks. I just kept thinking that my heart would break if she was limp and cold. It sounds odd but it was such a strong feeling.

Obviously this was our darkest moment. The thought of Kirsty fighting for her life and nothing we could do. We might as well have been on the other side of the world. My frenzied brain went into overdrive. If she died they would put her on a cold

slab in the mortuary. That hideously soulless place. If that happened I would stay with her until she was buried. I would fight anybody that tried to stop me. My baby girl would stay in my arms and God help anybody that tried to take her away from me.

Those thoughts remain as clear in my head as they were on that day because I never felt so strongly about anything. We had made a really close bond with other parents on the ward. All day they had been popping in asking for news, praying for Kirsty and sharing in our hopes.

When Dr Archer left our room no one else came in. I didn't blame them. There was a horrible feeling of sadness. Everyone was so involved in each other's journey and now nobody knew what to say.

On the very rare occasions that a child died on the operating table I always talked to the parents myself. It was something I dreaded, the very worst part of my job.

The entrance to the theatre complex opened automatically onto the hospital corridor. I was immediately confronted by eyes full of grief and desperation. I remember Becky saying, 'Please save my little girl.' I was poleaxed and said nothing. Archer looked desolate. He'd already done the difficult job. I turned back to the sombre theatre, put on a new mask and scrubbed up again.

The anaesthetist had finished yet another cigarette, and said, 'Things are no better. Can we turn the pump off?'

'No, I'm going to try one more thing. Turn the lungs off. Run the camera again.'

This was my last-gasp attempt. It was something that could only be justified by invoking the laws of physics and had never been done before in a child. The tension on the wall of Kirsty's scarred left ventricle was elevated because of the size of the cavity. From a recent conference I knew that a Brazilian surgeon had made a series of failing adult hearts smaller when a tropical infection, Chagas disease, had weakened the muscle. The operation had been attempted for other types of heart failure patients in North America but was quickly discredited and abandoned. In my view, this bold approach was Kirsty's last hope.

I was not going to risk stopping the heart again, so I took a glistening new scalpel and cut the beating left ventricle wide open from apex to base, just like unzipping a sleeping bag. I began in an area of scar, carefully avoiding the muscles that support the mitral valve, and the filleted heart immediately fibrillated in response to cutting. This was fine because there was no risk of it pumping air.

Frankly I was stunned by the unexpected appearance of the inner lining of the heart. It was covered in thick, white scar tissue. To reduce the diameter of the ventricle I cut away the scar tissue on either side of the incision until I reached bleeding muscle and then removed one third of the circumference of the chamber. In an attempt to stop the mitral valve from leaking I sewed the central point of its two leaflets together, turning it from an oval to a double orifice structure resembling a pair of spectacles. Then I simply sewed the muscle edges together with a

double row of stitches to close the heart. In the end, this much smaller heart looked like a quivering black banana. Not for a moment did I think it would ever start again – and nor did my colleagues. Most of them thought I was crazy.

Word of the bizarre operation in Theatre 5 soon spread. The curious gathered to watch and the camera kept on filming. We had to ensure that all air was removed from the heart, otherwise it could be ejected into the blood vessels of the brain and cause a stroke. After that, all that remained was to defibrillate and try to restore normal heart rhythm.

'We're done,' I announced. 'Try 20 volts.'

Zap! The heart stopped quivering, and for what seemed like an age there was no spontaneous electrical activity. I poked the muscle with forceps and it contracted in response. This time there was a flicker on the blood pressure trace. Miraculously, the black banana had ejected blood into the aorta.

The anaesthetist looked again at the echo. 'It certainly looks different. Shall we try using the pacemaker?'

I was already sewing the fine pacing wires into place. We arbitrarily set the pacing box rate at 100 beats per minute and switched it on. I told the perfusionist to cut back on the pump flow rate and leave blood in the heart to see if it would eject consistently. It did. What's more, the echo showed that the mitral valve no longer leaked. At this point I felt that we were in with a chance. Life really does depend upon physics and geometry.

It was now after midday. Kirsty had been on the bypass machine for more than three hours and we needed to get her off it. As if timed to perfection, her own heart rhythm suddenly broke through the pacing. Coordinated natural heart rhythm is much more efficient than electrical pacing, providing much better blood flow and pressure.

It was like switching on a light in the operating theatre. Gloom changed to elation, adrenaline kicked in and my fatigue suddenly lifted. We gave Kirsty an infusion of adrenaline to help her heart take over from the bypass machine. Finally I gave the instruction to 'come off slowly'. We still expected her blood pressure to fade, yet the curiously reconfigured little heart kept on pumping.

'Off bypass. I don't believe it,' said the anaesthetist.

I remained silent, but I looked over my mask at Katsumata. He knew that I'd had enough by now.

'Let me finish,' he said.

'Sure.'

I took a last, disbelieving glance at the little black banana pumping away, then turned to the echo screen, where the incomprehensible flashes of white, blue and yellow were also reassuring, like a blazing fire. We could see blood streaming through the new left coronary and a double jet entering the left ventricle through the mitral valve – a curiously reconfigured baby's heart that finally worked.

After the encounter at the theatre door both Archer and the parents believed that Kirsty had died. This created an unprecedented and awkward situation, but one that I was too knackered to deal with. I asked the anaesthetic nurse to bleep Dr Archer and ask him to come down yet

again. She did this, then offered to get me a coffee.

Katsumata made certain that there was no bleeding, then meticulously closed the chest.

'Never been done before,' he said, looking over at me.

Soon afterwards Becky came down to the theatre in shock. She put her hand on Kirsty's little foot and exclaimed, 'It's warm. It's never been warm.' When she started to cry I left. It had been a long day.

Dee, my endearing and eccentric secretary, drove me home to Bladon, some twenty minutes outside Oxford. I was restless, with a mixture of elation and fatigue. A huge, red, wintery sun was setting over Blenheim Palace. To wind down I set out to run around the lake with Max, our German shepherd dog. Through the ancient oaks we scattered rabbits and fortunate pheasants who'd survived the shooting season. The shadows lengthened. Hissing swans told Max to piss off. The sun slipped away as I staggered by the water's edge. I left the park at the Bladon gate, crossed the road and went into the grounds of St Martin's Church.

Winston Churchill is buried in the graveyard. Facing his tomb – invariably surrounded by dead flowers with their heads dipped in reverence – is a wooden seat donated by the Polish resistance from the Second World War. Hot, and gasping for breath, I sat down to talk with the great man, less than ten feet away in his box. Morbidly, I tried to visualise how his corpse looked now and contemplated how Kirsty at that moment could so easily have been stiff and cold in the hospital mortuary. But I'd followed his dictum – never surrender.

Max irreverently cocked his leg on a neighbouring tomb. Now I needed to sleep. I hoped that the phone would leave me in peace. It did. Kirsty survived.

We followed her carefully over the following ten years, using echocardiography to watch her heart develop. She was a perfect little girl, happy, outgoing and energetic, the only clue to her extraordinary internal metamorphosis being the faint stripe up the middle of her chest.

When we felt she was mature enough to discuss it we asked for her permission to carry out a magnetic resonance imaging scan to show us how the remodelled heart had developed. What we found was quite extraordinary. Apart from the double-orifice mitral valve her heart appeared normal, as did her new left coronary artery. Only the thin nest of scars showed the position of the line of stitches up the heart. Remarkably, all other scar tissue had disappeared. The whole inner lining of her left ventricle had been pure white scar tissue – now all gone.

This provided some of the first evidence that an infant's own cardiac stem cells can regenerate heart muscle and actually remove fibrous tissue. Adult hearts cannot recover in the same way. But what if we could identify and culture stem cells that could do just this for an adult heart? Could it provide a solution for the hundreds of thousands of adult chronic heart failure patients with coronary artery disease? My grandfather was someone who might have benefited. We could inject the cells at the same time as their coronary bypass surgery, or get them in through a catheter within the heart. What cells would

we use, where would we find them, and how could we preserve and transplant them? One day I'd find out.

Now aged eighteen, Kirsty is a vivacious and athletic teenager, but had she died we'd never have known about this exciting possibility for heart regeneration.