



What Surgeons Can Learn from Polar Explorers and Fighter Pilots Professor Roger Kneebone

6 January 2021

Surgery as Performance

This lecture forms part of a series in which I examine the concept that clinical practice may be considered as performance. In this tenth lecture I explore those aspects of operative surgery that relate to how people work together in real time to carry out operative procedures on patients - and how clinicians deal with issues of risk, error and resilience. I draw on my own experience as a trauma surgeon, working in Southern Africa in the 1980s; my seventeen years as a general practitioner (GP) in a large group practice in the southwest of England; and my current role as an academic at Imperial College London.

In this lecture I further develop the idea that medical practice takes place at an intersection between scientific knowledge, psychomotor skill and performance - and that performance is that aspect of practice which patients are most aware of. Previously I have discussed several elements of clinical practice that resonate with experts outside medicine altogether. These include team working (with puppeteers); close-up live performance (with magicians); craftsmanship (with a bespoke tailor); and improvisation (with a specialist in classical music improvisation). Today's lecture draws on perspectives from two high-risk professions outside medicine - polar exploration and combat aviation. These notes provide a summary of the lecture's introductory content. Many of its ideas will be developed further through conversation, in the lecture's second part.

The Path to Mastery

Dealing with risk and error is an integral part of becoming a skilled and experienced professional. In my recent book *Expert: Understanding the Path to Mastery* (published by Penguin in August 2020) I outline the stages that people go through as they become expert. I draw on the model, familiar to many people, of the mediaeval guild system. This sets out three stages - apprentice, journeyman and master - which anyone learning a trade was expected to pass through. (I should point out that I do not use these terms in a gendered sense). Each stage takes many years.

As an apprentice you are working in a master's workshop, doing what you are told, whether you like it or not. You are largely insulated from the consequences of error as it is expected that you will make mistakes. As a journeyman you leave your master's workshop and move out into the world, 'journeying' across your country as you ply your craft or trade as an independent practitioner. Now you take the credit for your work, but also the responsibility for the errors you will inevitably make. Finally, as a master, you reach the point where you can set up your own workshop and pass your knowledge on to others, including apprentices who are starting their careers. And so the process continues.

This model is helpful in some ways, because its outlines are familiar. But it provides a description rather than an explanation. It makes the path to mastery seem much simpler than it actually is. It overlooks the frustrations and struggles that everyone experiences along the way. It does not show the internal processes that everyone must go through as they gain skill, knowledge and wisdom. It glosses over the time it takes to build up experience through doing and it hides the many times when

people may be tempted to give up, to throw it in and to do something easier. And it can overlook the inevitability that unexpected things will happen.

In my book I spend a lot of time exploring the things that go wrong and the strategies people develop for coping when that happens. Making mistakes or errors is an inevitable part of learning to do something. It's not something we can eliminate, though we can mitigate its effects. The crucial thing is how we respond to it when it happens - whether we can turn error into an enriching experience that deepens our wisdom, or whether we allow it to shiver our confidence and diminish our sense of worth. This lecture explores how insights from outside medicine can inform clinical practice.

Trauma Surgery - a Personal View

To set the scene I'll start with an experience from my surgical career which I describe in my book *Expert*. It happened at Baragwanath (now Chris Hani Baragwanath) Hospital in Soweto, on the outskirts of Johannesburg in South Africa. At that time (the 1980s), Soweto was one of the most violent places in the world. I worked there for several years while I was training as a general and trauma surgeon, passing through the initial stages of the pathway I describe in my book.

In the following excerpt I recall an occasion when I was operating at night on a patient with penetrating chest and abdominal wounds. 'I didn't even know the patient's name at the time', I write, 'as he was almost dead from blood loss when he arrived. We had to take him straight to theatre. As I finished dealing with his abdominal injuries, his condition plummeted and I realised I had to go into his chest. The knife that stabbed him must have been a long one, as there was bleeding from the great vessels near the heart. I hadn't seen much thoracic surgery, let alone done any, and yet again I was way outside my comfort zone. But there was no alternative, so I carried on'.

'Thoracic surgery is a specialised field and needs specialised instruments. After opening the chest, I found that blood was hosing from one of the large vessels to the lung. I could see where it was coming from, and I needed to stop it fast if my patient was to survive. In this kind of emergency you can't take your eye off the site of injury, and your scrub nurse plays a vital role by putting what you need into your hand. On this occasion, the nurse with me hadn't done much thoracic surgery either. I asked for an angled clamp to control the bleeding, held out my hand and felt the instrument's handle hit my palm. I was just about to place it across the fragile vessel when I realised that, instead of the soft vascular clamp I was expecting, she had given me a bronchial clamp. This has murderous spikes in its jaws, designed to grasp the stiff cartilage of the air passages. It would have cut the delicate pulmonary vessels to shreds. To this day, I can feel the pounding of my heart as I realised what a narrow escape my patient and I had both just had'.

Looking back on that experience now, I recognise it as a 'near miss', where a conjunction of circumstances could have led to disaster. My inexperience and that of my fellow surgical team members, the stress of operating on a part of the body I was unfamiliar with, the urgent nature of the case, and a lack of senior support at the time came together in a combination that was potentially hazardous. I was aware of an urge to take immediate action, to intervene and to clamp something - an urge which interfered with my ability to think round the situation calmly. Though in this instance the immediate danger was averted and my patient made a good recovery, the effect of that experience upon me has been long lasting. Decades later it prompted me to reflect on the nature of error and recovery.

'Error has a bad name', I go on to write in my book, 'but it's both important and unavoidable. The challenge is not to eliminate it but to minimise the damage it causes. There's a difference between 'bad error' (those harmful mistakes that should have been avoided) and 'honourable error' (when you try something and it doesn't work). There's no shame in honourable error. On the contrary, it's how people move forward. Error then becomes something to learn from, something to be

experienced, corrected and reshaped, rather than avoided altogether. Nobody sets out to make mistakes, but learning from error is an essential part of becoming expert. It's how you improve. Error and failure are not the same'.

Exploring Points of Connection

As well as looking back to my experience as a trauma surgeon in Africa, often working at the limits of my skill and experience, I draw on my later experience as a GP. There again I was having to make decisions that could have serious implications for my patients, though usually in less dramatic circumstances than dealing with torrential bleeding in the operating theatre. For example I would often have to decide whether to admit a child with worrying symptoms to hospital, or whether it would be better to keep them under review at home. These decisions had serious implications and I often felt uncertain whether I had made the best choice.

Now, decades later, I work at Imperial College London, a large university. Much of my work involves teaching students and surgeons about education. In 2019 I brought together a small group of expert performers from widely differing fields to share their experiences and explore what we could learn from one another. That meeting provided the seed for this lecture.

The group consisted of a fighter pilot (who had recently left the RAF after a long career in combat flying and training other pilots); a polar explorer (who led expeditions to the Arctic and Antarctic from the Cavendish Laboratory in Cambridge, was Deputy Director and Acting Director of the British Antarctic Survey, and became a General Manager with a strong interest in risk management in the oil and gas and insurance sectors); a consultant upper gastrointestinal surgeon (who carries out challenging cancer operations on the stomach and gullet); and a leading classical guitarist (with a distinguished career as a soloist, recording artist and ensemble player). Over the course of a day we shared our experiences and ideas around risk, error, recovery and resilience. Our aim was to identify areas of overlap and consider how insights from these different domains of professional practice could be applied across disciplinary boundaries. I was especially interested in how these insights could improve the world of medicine.

Managing and Mitigating Risk

There was a consensus that working with risk was an integral part of all our work. The challenge was not to avoid risk altogether but to recognise and manage it appropriately. The surgeons, the fighter pilot and the polar explorer all worked in fields where people could suffer serious physical harm if things went wrong - either as a 'performer' (a combat pilot flying at near supersonic speeds in a hostile sortie, or an explorer leading a polar team in extreme conditions) or as someone whose health and safety depended on an expert professional (a patient undergoing complex cancer surgery).

In each of these settings it is impossible to eliminate risk, and the possibility of error is ever-present. Recognising, gauging and managing the level of risk is complex and demands years or decades of experience. There are similarities too with the world of elite musical performance. Although nobody dies or gets physically injured in a concert hall or live radio performance, the impact of error on a performer's confidence and career can be devastating.

The members of the group agreed that they had each learned about managing risk and error within the compass of their professional group. Fighter pilots learned from fighter pilots, explorers from explorers, musicians from musicians and surgeons from surgeons. There seemed no forum for experts from radically different backgrounds to share their insights. Yet in the process of conversation it became clear that all participants had parallel experiences and had developed approaches which could benefit others.

Error or Complication?

Much has been written about the nature of risk and how people assess and handle it. Awareness of risk is culturally inflected. The explorer in our group pointed out that in many parts of Africa, for example, people's acceptance of risk in the context of everyday driving was strikingly high. Risk in that setting was part of a wider culture. When he took on responsibility for safety within a major energy company, he introduced (among many initiatives) advanced driving training for employees in Africa that dramatically reduced the incidence of road traffic accidents and consequent injury.

Varying responses to risk are especially evident in the context of clinical care. From my clinical perspective, discussing, explaining and weighing risk is part of every surgeon's practice. Yet how do you convey a realistic sense of risk to a patient who is considering surgery? From a professional's viewpoint, risk is often expressed probabilistically. Putting together evidence from the literature with data from their own hospital, a surgeon might say that the risk of a particular complication after a given operation is 1 in 100. If that hospital carried out a thousand operations of that kind in a year, ten patients would suffer that complication. Yet a patient hearing those figures might interpret them as meaning that the likelihood of suffering that complication was vanishingly low - and that the risk to them was negligible, even virtually non-existent. As patients, we tend to interpret risk in a binary, rather than a probabilistic way. We ask: are we likely to get that complication or not? Yet risk cannot be reduced in such a simple way.

An important distinction in surgery is between complications and error. Every procedure or treatment has a complication rate, and it can usually be expressed as a percentage. You might say that x% of patients will experience an anastomotic leak after a bowel resection - a leakage after a section of diseased intestine has been removed and the cut ends joined together. Nobody can know in advance which patients that will happen to - but a probabilistic approach allows surgeons to state pretty accurately how often it will happen. These complications are not because the surgical team is incompetent or anyone has made a blunder - it's just that operating on living people entails uncertainty. Every patient's body heals differently and every so often these things will happen.

Sometimes, of course, an avoidable mistake does happen. This is caused by human error - through inexperience, ignorance, unwise choice of procedure, incompetence or many other causes. This is quite different from that inevitable complication rate I have described above. To the patient and the surgeon, though, the impact of anything going wrong can be devastating, whatever its cause. Of course we need to do everything we can to make sure that errors don't happen. But complications always will. As a clinician it's easy to interpret all bad outcomes in terms of error when in fact they may be complications - the inevitable corollary of doing a large number of operations.

Recovery and Resilience

The discussion so far has focused on dealing with risk and error, exploring how this plays out in the different worlds of surgery, combat flying and polar exploration. Its focus has been on the impact of risk and error on people who take part in activities with the potential for damage. Another kind of damage - less obvious but equally destructive - is the impact on professionals' confidence and self-esteem when something goes wrong. Going back to the pathway to becoming expert which I describe in my book, learning to deal with error and complications - not ignoring their impact or minimising their importance, but not allowing them to destroy your confidence either - is a crucial part of moving ahead and building the experience that leads to mastery.

At the heart of this is the idea of resilience. Summarised by one author as 'the ability to bounce back or cope successfully despite substantial adversity' (Rutter, 1985), this area has attracted much attention in recent decades. Yet ideas differ around how resilience should be conceptualised. Core

questions include the nature of adversity and positive adaptation, including responses to ostensibly positive events (such as job promotion) as well as negative ones (such as professional setbacks or disasters). There is debate about whether resilience is a trait or a process that changes over time. Although someone may react positively to adversity at one point in their life, they may react differently to stressors at another time. Several writers point out that resilience is a capacity that develops over time in the context of interactions between people and the environments they are in. If circumstances change, resilience alters.

Moving along the path to becoming expert involves transitioning from one professional role to another. My own experience of progressing through the surgical hierarchy involved several jumps in responsibility, such as becoming a registrar or a consultant. At each point I needed resilience in order to take advantage of new opportunities for experience without feeling hopelessly out of my depth. This is as much about developing the capacity to establish supportive relationships as about the details of the activity itself.

Other authors write about resilience as the interactive influence of psychological characteristics within the context of the stress process (Fletcher & Sarkar, 2013). Resilience influences how an event is perceived - as distinct from coping, which is more about the strategies people use after they undergo a stressful experience. Being exposed to adversity (at least within limits) can allow people to mobilise untapped internal resources, connect with social support networks and establish a sense of agency and control which builds capital for dealing with future adversity.

Practical Insights

The discussion event outlined above provided numerous insights from the worlds of surgery, exploration, combat flying and music - areas of activity in which risk is ever-present but which seldom have the opportunity to connect with one another. They included the following advice.

1. *Beware of making assumptions.* Look and think carefully before you take any irrevocable step. For example, removing the gallbladder is one of the commonest operations in general surgery. Usually it's an extremely safe procedure. Yet the anatomy around the gallbladder can vary from patient to patient. Occasionally a surgeon inadvertently divides the common bile duct - a crucial structure which carries bile from the liver to the intestine. This is a major disaster. When that does happen, it's often because the surgeon 'misreads' what he or she sees, misinterpreting a normal anatomical variation for an abnormality and cutting the wrong structure. Such 'unforced errors' stem from making assumptions. This is a danger in every field, even when rigorous safety procedures are in place.

2. *Design places of safety in advance.* This allows you to press 'pause' in a challenging situation and provide time to think. Many experts describe having worked out in advance what a 'safe place' might mean for them. For a cancer surgeon it might involve having large packs immediately available to control sudden bleeding when starting a difficult dissection, or knowing in advance where to find an experienced colleague if unexpected difficulties emerge. For a polar explorer it might mean recognising when it's too dangerous to press on in bad weather and poor light, constructing an emergency bivouac and waiting until morning to conserve energy. For an ensemble musician it might mean stepping out of the limelight if you have a problem with your own performance, then 'getting back into tempo' with the others while you recover before resuming your part.

3. *Use checklists where appropriate.* There is a lot of talk about checklists and how useful they can be in ensuring that key steps are not overlooked. Checklists 'provide a handrail when you're walking down the stairs', as Phil Bayman the fighter puts it. This can be extremely helpful. But they should not take the place of careful design and preparation. In fast-moving situations, long checklists can cause distraction and clog your mind at a time when you need maximum flexibility. Remaining alert

to the unique features of each situation is a key skill shown by experts.

4. *Remember that your brain can play tricks.* Phil the combat pilot described how people often go through checklists by saying 'yes' after each item as they tick it off. Occasionally they say 'yes' without actually having performed the relevant action, but still believe they have done it. Phil himself describes how some years ago he was about to land his fighter jet, having gone through his pre-landing checks. Glancing down at his instruments he suddenly realised that instead of seeing the green light which confirmed that the undercarriage had been lowered, the light was still black. With no time to work out what had happened or why, he instinctively put on full power and gained height. Only when he had reached a safe altitude could he replay events in his mind. He realised that although he had gone through the 'lower the landing gear' item in his checklist, he hadn't actually performed the action. If he had stopped to analyse the situation in detail he would have crashed and died. But he recognised that something was wrong and took immediate action to reach a safe place where he could draw breath and consider his options before deciding what to do next.

5. *Test resilience for low probability, high severity events.* These are scenarios that could happen and should be planned for. In the case of governments they include pandemics. For oil and gas companies, they include catastrophes such as offshore oil or gas platforms catching fire or oil tankers running aground and spilling their cargo in ecologically vulnerable locations. In the case of fighter pilots, they might include sudden mechanical failure or 'controlled flight into terrain' (accidentally crashing into the ground while still in full control of the aircraft). Senior managers have to make tough decisions on what resources to dedicate to responding to rare events like these. Whatever their nature, it's better to plan for these unlikely yet potentially devastating situations than to cross your fingers and hope they never happen.

Conclusion

If surgery is framed as performance, many parallels with other areas of expert practice come into view. When faced with the unexpected, it is tempting to take definitive action at once. But often the better course is to stabilise your situation and take time to consider your options before committing yourself. Returning to my experience in the operating theatre in Soweto in the 1980s, I realise the need to pause and take stock before taking an irrevocable step.

Initial work has shown how thinking beyond disciplinary boundaries can open new ways of thinking. This lecture explores some of these parallels further and identifies insights and techniques that may enrich the safety and quality of work for all who take part.

Acknowledgements

I am grateful to the following people for their generosity, time and insight

- Dougal Goodman (explorer and risk management expert)
- Phil Bayman (combat pilot and human factors coach)
- Chris Peters (consultant surgeon)
- Petur Jonasson (classical guitarist)
- Terry Clark (research fellow in performance science)

© Professor Kneebone, 2021

References

Earvolino-Ramirez, M. (2007). Resilience: a concept analysis. Nursing Forum. <https://doi.org/10.1111/j.1744-6198.2007.00070.x>

- Fletcher, D., & Sarkar, M. (2013). Psychological resilience: A review and critique of definitions, concepts, and theory. *European Psychologist*. <https://doi.org/10.1027/1016-9040/a000124>
- Kneebone, R. (2020). *Expert: Understanding the Path to Mastery*. London: Viking Penguin.
- Moulton, C. A. E., Regehr, G., Mylopoulos, M., & MacRae, H. M. (2007). Slowing down when you should: A new model of expert judgment. *Academic Medicine*. <https://doi.org/10.1097/ACM.0b013e3181405a76>
- Pelletier, C., & Kneebone, R. (2016). Learning safely from error? Reconsidering the ethics of simulation-based medical education through ethnography. *Ethnography and Education*. <https://doi.org/10.1080/17457823.2015.1087865>
- Rutter, M. (1985). Resilience in the face of adversity: Protective factors and resistance to psychiatric disorder. *British Journal of Psychiatry*. <https://doi.org/10.1192/bjp.147.6.598>
- Ungar, M. (2011). The social ecology of resilience: Addressing contextual and cultural ambiguity of a nascent construct. *American Journal of Orthopsychiatry*. <https://doi.org/10.1111/j.1939-0025.2010.01067.x>

Questions & Answers

1. How do we train people to recognise when the models they have been trained on are no longer relevant / actually becoming dangerous and need to be ditched in favour of improvisation based on experience? (Mark Russell)

Answer: I think we need to highlight the importance of thinking analytically about our own performance and not taking things for granted. Many experts in safety-critical industries have clear systems for reviewing and debriefing, and these can help in not becoming complacent.

2. Is one issue learning through experience when it is necessary to set a new goal? (Val Kerr)

Answer: I'm sure that's important. We sometimes think of goals as fixed, but I think they are often provisional and need to be revised as we get closer to them.

3. Shaking up teams can be positive though - reduces risk of groupthink / reluctance to speak up if things are not as they should be (Bristol Children's Hospital heart surgery issues)? (Mark Russell)

Answer: I quite agree. Shaking up teams is necessary at times – though there's a balance to be struck between acting decisively if things are not working well or safely (as with your example) and meddling gratuitously when things are going fine. Not easy.

4. A question, does it help to 'practise' improvisation by regularly moving outside your comfort zone? (Carrie Walker)

Answer: I'm convinced that it does help to move outside your comfort zone. And often you find you can apply things you've learned in a different context to the new one you're in, which can be confidence-building.