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On acquiring decision making skills for endovascular interventions

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Dear Editor-in-Chief and Editorial Board of EuroIntervention,

We are all aware that performing endovascular interventions safely and effectively, requires a number of skills. Guidelines and "credentialing" policies are available regulating the formal training and other requirements[1,2]. However, to date surprisingly little guidance is available regarding the actual process of skill acquisition. Traditionally, interventional skills are obtained by observing and imitating master interventionists. But since the requirements posed on the interventional quality of practitioners are ever-increasing, the empirical trial-and-error approach, with its resulting slow transfer of the currently mostly tacit knowledge, is no longer sufficient. Here, we propose a novel approach based on cognitive learning of skills for explicit rational decision-making.

Rational structure of endovascular interventions

Endovascular interventions can be formally divided into three basic phases: initialisation, main interventional cycle, and termination. Initialisation begins with the skin cut prior to needle puncture and ends with the positioning of the tip of the guiding catheter at the target ostium. The main interventional cycle, or MIC, begins with acquisition of the baseline angiograms of the target site and ends with the acquisition of the final angiogram. Termination begins with the removal of the instrumentation and ends with the closure of the access site[3]. MIC contains one, a few or many rounds. Each round is composed of a decision (including a rationale), an action, and an outcome. An action is either an interventional or a diagnostic step. The minimum of number of rounds is N=2. The decision involves uncertainty about the actual situation and the action has to accommodate uncertainty about its outcome. Both are, hence, necessarily accompanied by risk.

Interventional decisions: rules, recommendations, strategies, modules and tactics

Interventional decisions are based on a small set of strict rules and a larger set of less strict recommendations. Examples of interventional rules include imperatives such as "Always advance the instrumentation under fluoroscopy control." and"Always keep air out of the catheter systems." Examples of recommendations include statements such as "In the presence of multiple lesions of the target vessel, approach the most distal lesion first." and "Do not revascularise non-culprit lesions in emergency cases". Most of the rules and recommendations are well known, but they are rather unspecific, covering only very little of the decision space in which an interventionist has to operate.

The nature of the intervention is that of a sequential, iterative process: The decision in round N is based on the outcome of the previous round N-1. Skilled interventionists, however, usually form an expectation about the most likely course of the intervention as a whole. This expectation is based on the interventionalist's experience about sequences of actions that are useful and consequences that are likely. We call such an expectation an interventional strategy: A rough plan of action aimed at good outcome with minimal risk - which usually implies keeping the number of rounds as low as possible using the most suitable instrumentation. Interventional strategies are patient-specific and are formed by skilled interventionists based on good clinical judgement. The mental representation of each MIC round in an interventional strategy we call an interventional module: A description of an intermediate situation that is common during an intervention, the

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decision for this situation and corresponding rationale, the respective action to be taken, and the outcome that is both expected (i.e., likely) and intended (i.e., it represents positive progress in the intervention). The set of interventional modules from which the strategies are composed is not small, but limited (probably a few hundred). Each module is a prototype of a common, successful, and useful interventional step and together they capture the behaviour a skilled interventionist intends to exhibit. In contrast to the patient-specific interventional strategies, the interventional modules are all generic. We postulate that a comprehensive set of proven interventional modules would be a sound and most useful basis for forming good interventional strategies and hence for developing interventional decision making skills. An effort at establishing a library of well documented teaching cases and collecting such a set of modules should thus be made. Ideal interventions just follow the interventional strategy. In the imperfect world of clinical practice however, even the conduct of master strategies with modular characteristics may produce unexpected outcomes resulting in the need for deviations and improvised interventional actions. Thus, less-than-ideal interventions at some point produce an outcome not foreseen when choosing the interventional strategy and require a change of the plan. We call such a change an interventional tactic and the associated rounds improvised actions. Minor changes include the insertion of additional steps according to a known interventional module to save the given strategy; major changes involve inserting one or more uncommon steps (i.e., steps that do not conform to any standard interventional module), switching to a different strategy, or in rare cases premature termination of the procedure. Just like interventional strategies, interventional tactics are patient-specific and even situation-specific. In contrast to interventional strategies, interventional tactics often have to be chosen under severe time constraints and hence require even higher clinical judgement skills.

A good strategy will predict the course of the intervention reliably and will therefore minimise the number of times at which an interventional tactic has to be applied. Interventions which do not deviate from interventional strategies are termed routine interventions, those which deviate are termed partly improvised interventions. "Actional" risk associated with routine interventions is lower compared to improvised interventions. The magnitude of procedural risk is related to the number of rounds and the number of improvised steps.

On acquiring decision making skills

Today, intermediate interventionists primarily acquire their good clinical judgement in two ways: by learning from their own personal experience (an empirical approach) and by learning from advice provided by master interventionists acting as mentors (a cognitive approach). In principle, a cognitive approach ought to be superior, because it does not require making each mistake (or other experience) oneself in order to learn from it. However in practice, the effect from cognitive learning is often small for two reasons: The availability of mentors is insufficient and their explanations tend to be difficult to absorb. They are difficult to absorb because the knowledge intended for transfer is largely tacit and it is well understood that it is difficult for experts to access their tacit knowledge, let alone to find good representations for expressing it[4,5]. We propose the rational concepts formulated above as a foundation for representing the tacit knowledge of expert interventionists such that interventionists can easily and systematically access it and learn from it cognitively.

Learning based on strategies, modules, and tactics

To externalise expert knowledge a series of teaching cases must be collected, analysed, and the generic interventional modules must be retrieved. Once the tacit knowledge of expert interventionists has been externalised, beginning and intermediate interventionists can cognitively learn decision-making skills in three stages as follows.

The fundamental stage is acquiring the interventional modules and learning in terms of risk[6]. In principle, each module can be learned separately, sometimes in connection to an actual case experienced in clinical practice. Mastering a module involves four capabilities:

1. Making the decision by recognising applicability. Is the situation one in which this module should be applied or not?
2. Performing the action. This may or may not go hand-in-hand with acquiring the necessary manual skills.
3. Judging the outcome. Has the module worked as intended or not?
4. Understanding the uncertainty involved in the initial assessment (knowledge risk), in the outcome (actional risk), and in the assessment of the outcome (knowledge risk).

The second stage consists of learning how to create good interventional strategies based on these modules. The critical skills here are chaining modules in such a manner that indirect risk is avoided, that the strategy is robust against the knowledge risk involved in the initial assessment of the situation and against the uncertainty of module outcomes, and that global parameters such as cost, time-on-table, and total actional risk are optimised (see ref. 3 for discussion of the risk categories). Mastering stages one and two together enables an interventionist to perform routine interventions effectively, efficiently, and with minimal risk.

The third stage consists of acquiring a habit of learning by reflection to improve design of strategies and learning how to handle unexpected outcomes: How to craft a useful interventional tactic, how to decide when to switch to a different strategy instead, and how to judge whether a tactic's outcome was adequate given the circumstances. Stage three enables an interventionist to optimise the risk/benefit ratio even when an intervention breaks out of its expected path and thus to master non-routine interventions.

The knowledge used in stage two consists of a set of heuristic rules and recommendations that are applied and combined in conventional ways. The knowledge used on stage three consists of the same plus a few additional heuristic rules and recommendations that are applied and combined in less standard ways, assuming higher uncertainties and accepting higher risks.

Summary

To improve interventional training we propose a staged rational approach for decision making and skill acquisition. Education and training for endovascular interventions should start to develop the

learners' decision-making skills by learning from explicit representations of master interventionist's tacit decision-making knowledge through implementation of the notions of generic interventional modules, interventional strategic and tactical designs. We hope that these suggestions will encourage action, stimulate dialogue and advance the precision of our learning, procedures, practice and patient care.

Thank you.

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