INTRODUCTION

The concept of evidence-based medicine (EBM) assumes
that current medical research, along with individual clinician judgment, can optimally guide clinical decision making to result in the best possible patient outcomes[1,2]. While EBM requires the use of best available evidence, multiple challenges may arise in its practical application to spinal surgery. For instance, rare disorders result in small patient numbers and subsequent lower quality data. At the other extreme, randomized controlled trials (RCTs) attempt to generate high quality evidence, yet are hindered by expense and difficulties in study recruitment and conduct.

Despite the challenges involved with EBM, it is the future of medicine[3]. If spine surgeons do not want poor-quality studies to dictate and limit their clinical decisions, then responsibility rests with this group of practitioners to design high quality studies to justify certain treatment modalities.

This review therefore highlights the tenets of implementing evidence-based research, through the lens of spinal disorders. Techniques of conducting and evaluating EBM are first discussed, followed by a review of pertinent outcome measures in spinal surgery. It is the authors’ goal that these basic tools will provide a basis of EBM for the practicing spinal surgeon.

TECHNIQUES OF EBM

Asking the correct question

Before a study is designed, a research question must be asked. The importance of the research question lies in the fact that it dictates a study’s design. Often, the RCT is considered the gold standard of evidence-based medicine, yet the research question may exclude the RCT from feasibility or utility. For example, a question of superiority in treatment protocols, where each treatment has equipoise for the surgeon and patient, is suitable for a RCT. However, a question may best be answered with a prospective cohort design if there are subjective treatment preferences among surgeons, the presence of significant selection biases, or poor generalizability[3].

A well-designed and focused research question will not only dictate the study design, but will also aid in literature searches. Instead of turning up hundreds to thousands of citations, a well-defined question will limit the pertinent literature to a manageable number that allows a focused interpretation.

In addition, the research question will permeate through a central theme of the research manuscript. The question should be stated in the introduction of a manuscript, and contain the intervention of study and cohort of interest. Returning to the research question throughout the manuscript will allow reporting of more concise results and a more pertinent discussion.

Designing the study

Once a research question is proposed and a formal review of the literature is performed, the study design is implemented. Table 1 highlights the advantages and disadvantages of various study designs. A case series tracks patients with a known pathology given similar treatment, and allows assessment of a clinical course based on that treatment. Case series are often retrospective but may be prospective. They are often confounded by selection bias, limiting elucidations of causal relationships. Case series may be improved, however, with well-defined selection criteria and the use of validated outcome measures. For rare spinal disorders, a case series may be the best available evidence.

A case-control study design is a type of observational study, wherein two patient groups with differing outcomes are identified and compared for a supposed causal attribute. They are retrospective in nature and relatively inexpensive. Because of their retrospective nature, however, there is difficulty in obtaining reliable information about a patient’s exposure over time. This effectively hinders the ability to make claims of causation.

A cohort study is also observational in nature. It follows a group of patients without a disease in order to determine risks of contracting that condition, or compares two treatment options. A cohort study may be retrospective or prospective in nature. It is beneficial for identifying the natural history of a disease, the risk factors of a disease, or the impact of an intervention. Cohort studies are more expensive and time consuming than a case-control design or a case series, with strict inclusion and exclusion criteria. Prospective cohort studies in particular are considered to yield the most reliable results in observational studies.

A RCT is considered the gold standard for a clinical trial. It is often used to test the effectiveness of a medical or surgical intervention within a well-defined patient population. The intervention is provided to the patient based on a process of randomization, in a blinded or unblinded manner. The RCT offers reliable evidence because it reduces bias and spurious causality. Nonetheless, RCTs are prone to high cost, administrative difficulties, and limited recruitment.

Spine surgeons in particular may struggle with obtaining a high quality RCT because of high crossover rates and low patient recruitment. In addition, it is relatively difficult for surgeons to design a study that randomizes patients to interventions that are typically used in sequence[3]. For example, a RCT may be designed to compare operative vs non-operative treatment of neck pain. Most surgeons, however, consider failure of non-operative measures as an indication for surgery. Therefore, a patient in this study would need to accept being randomized to a non-operative treatment modality that s/he has already failed. If the concept of equipoise is used in an attempt to circumvent this problem, then surgeons may be relegated to operating on patients without clear operative indications. In this example, a supposed state of equipoise could lead to a surgeon operating on a patient with neck pain who has not failed conservative measures, further confounding results and perhaps leading to poorer surgical outcomes.

Because practical and ethical reasons may prevent the initiation of a RCT, strong observational alternatives are
needed in spinal research. This notion would circumvent the impossibility of randomizing every component of intervention.

Systematic, evidence-based literature reviews provide a summation of the available literature on a topic. This type of study is valuable as a synopsis of previously-reported data, aiding understanding of outcomes, safety, risk factors, and impact of spinal surgery intervention. Systemic reviews should be transparent, so that data is presented in an unbiased manner, thus allowing the surgeon to make independent conclusions based on the data. A quantitative synthesis of high quality data is termed a meta-analysis, which may be useful when pooling studies which are individually under-powered to find conclusive results.

Assessing the level of evidence

Based on study design, the level of evidence for an intervention can be assessed (Table 2). RCTs are categorized as level I or II. Cohort studies are level II or III. Case-control studies are level III, and case series are level IV. Expert opinion is considered level V. The level of evidence correlates with certainty of risks and benefits of a given intervention, so that higher levels of evidence (and thus higher quality studies) provide more certainty in their conclusions, and therefore stronger recommendations for treatment.

Although a majority of studies in spinal surgery are of levels III and IV, a select number of studies are of higher level evidence. Certainly the level of evidence, however, is not the final answer in evaluating the literature. The lack of RCTs in spinal surgery research reflects the complexities and limitations of this study design. In addition, the current system of analyzing levels of evidence ignores whether the study asked the correct question or examined the relevant patient population.

OUTCOME MEASUREMENTS IN SPINE RESEARCH

The use of standardized outcome measurements is important for conducting evidence-based research. The quantification of patient symptoms, ability to perform activities of daily living, and overall health status is necessary to track patient progress as well as to conduct clinical studies. Outcome measurement tools allow clinicians to communicate, in a standardized manner, the success of treatment strategies. However, there is no standardized set of clinical outcome measures for all spine patients. Outcome measurements for those with cervical pathology differ from those with lumbar pathology, for example. The questionnaires given to the patient must be carefully selected so as to elicit the most pertinent information in

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**Table 1** Types of study design

| Design type            | Advantages                                      | Disadvantages                                      |
|------------------------|-------------------------------------------------|----------------------------------------------------|
| Case series            | Suitable for rare diseases or new treatments    | No comparison group                                |
| Case control           | Small sample size                               | Retrospective nature                               |
| Cohort studies         | Evaluates risk factors                          | Presence of confounding                             |
| Randomized controlled trials | Prospective in nature                          | Presence of confounding                             |
| Systematic review      | Provides summation of available literature      | Limited generalizability                           |

Adapted from Fisher et al.

**Table 2** Levels of evidence

| Evidence level | Therapeutic studies: Evaluating results of treatment | Prognostic studies: Evaluating outcome of disease |
|----------------|-------------------------------------------------------|--------------------------------------------------|
| I              | RCT                                                    | Systematic review of level 1 RCTs                |
|                | Systematic review of level I RCTs                     | Systematic review of level 1 studies             |
| II             | Prospective cohort study                             | Poor quality RCT (e.g., < 80% follow-up)         |
|                | Systematic review of level III studies               | Systematic review of level II studies            |
| III            | Case control study                                   | Case control study                               |
|                | Retrograde cohort study                              | Systematic review of level III studies           |
| IV             | Case series                                           | Case series                                      |
| V              | Expert opinion                                       | Expert opinion                                   |

Adapted from Wright et al. RCT: Randomized controlled trial.
the most efficient manner. It is important to recognize that providing an excessive number of questionnaires will decrease patient compliance. The aim of this section is to highlight the outcome measurement tools commonly used in spinal surgery research (Table 3).

The oswestry disability index (ODI) is the most common questionnaire utilized to evaluate the physical symptoms of patients with low back pain, with an emphasis on quality of life. This questionnaire evaluates ten categories: pain, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling. There are six answers available per question with point values of zero to five; the maximum score is fifty. A quantification of patient disability may be calculated by dividing the point total by fifty then multiplying by one hundred percent. Those with 0%-20% disability are considered minimally disabled. A score of 21%-40% is moderate disability, 41%-60% is severe, 61%-80% is crippled. Those with scores of 81%-100% are bed bound. A change of 4 points is the minimum difference that can be considered clinically significant. A 15 point change, though, is what is considered significant for patients undergoing spinal fusion.

The neck disability index (NDI) represents a modification of the ODI for patients with cervical spine pain. The questions elicit information about activities such as concentration and reading which can be affected by cervical pain. Soft tissue injury can also lead to headache, which is also evaluated by the NDI. The scoring system is the same as that of the ODI.

The visual analog scale is a measurement instrument which quantifies patient subjective pain. It consists of a 10 centimeter line with one end representing no pain and the other end the worst pain possible. The patient indicates where on the line his or her pain is in relation to these two extremes. This outcome measure can be used to quantify generalized pain or any specific type of pain (back, leg, etc.).

Patients with cervical myelopathy may suffer from a constellation of disabling symptoms, but pain may be a relatively minor issue. The Japanese Orthopaedic Association (JOA) scale is an objective assessment of upper and lower extremity motor function, sensation, and bladder function. The highest possible score is 17. The JOA is specific for patients who utilize chopsticks to feed themselves. For those who do not, the modified JOA (mJOA) has been developed. The questionnaire has replaced the word “chopsticks” with “knife and fork”. The mJOA is therefore more often used in the United States compared to the JOA. In addition, the mJOA involves a highest score of 18, rather than the JOA’s high score of 17.

Those with spinal deformities, in particular idiopathic scoliosis, have a slightly different set of concerns and health issues than those with degenerative conditions. These patients are typically adolescents or young adults. The Scoliosis Research Society-22 (SRS-22) questionnaire targets 5 domains: physical function, pain, self image, mental health, and satisfaction with management of scoliosis. Each of the 22 questions contains 5 answers with point values from 1 to 5, with 5 being the best. The mean scores from each of the 5 categories are averaged to produce a single value. Studies indicate that significant point differences for the SRS-22 are: pain 0.6, function 0.8, self image 0.5, mental health 0.4, average sum score 0.5, and raw sum score 6.8.

The EQ-5D-5L is a questionnaire that investigates patient quality of life. It consists of 2 forms. The first assesses 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is associated with 5 statements; the patient selects the statement that most correlates with their condition. No point values are assigned to each statement. The second form consists of a 20 cm vertical line with endpoints labeled “the best health you can imagine” and “the worst health you can imagine.” Patients are asked to indicate where on the line they believe their present state of health to be. Given that no numerical score is calculated from the 5 questions, the data can be presented in a variety of formats.

Similar to the EQ-5D-5L is the Short Form-36 (SF-36). This is a health survey analyzing 2 general domains: physical health and mental health. There are 36 questions and 5 possible responses per question. Physical health is divided into physical functioning, role functioning, bodily pain, and general health. Mental health is divided into vitality, social functioning, emotional role functioning, and mental condition. The SF-36 consists of eight scaled scores, which are the weighted sums of the questions in each section. Each scale is directly transformed into a 0-100 scale on the assumption that each question carries equal weight.
Ultimately, an outcome assessment tool must be reliable, reproducible, specific to the outcome of interest, yet brief enough to promote compliance. For these purposes, an array of well-validated standardized questionnaires is available.

CONCLUSION
Evidence-based research in spinal surgery has received a growing amount of attention, not only from surgeons and scientists, but from government regulators and the lay press. With continued pressure to produce high-quality evidence for the success of spinal interventions, one must recognize that the RCT is not always the optimal study design for a given research question. Rather, prospective observational cohort studies may be more appropriate in certain circumstances, and would provide superior generalizability. In addition, case series and case-control study designs have their own utility, particularly in studying rare diseases and new treatment options. The use of validated outcome measurements will increase the quality of a given study design. Finally, evaluating spinal research with levels of evidence, I - V, allows for an objective measurement of study quality, yet this system does not account for whether the correct question was asked or if the correct patient population was studied. These issues surrounding EBM are important for spinal surgeons, as well as health policy makers and editorial boards, to have familiarity.

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