

Systems science medicine: A systems approach to the complexity in medicine

Myles Suehiro MD, FAARFM*

Hawaii Institute for Health and Healing LLC, Hawaii, USA

Abstract

Systems Science Medicine refers to the whole as being composed of many subunits that contribute to the function of the whole. The contribution may be non-self-regulating as a gear or may be autonomous and self-regulating as an organ.

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Introduction

In complexity one may have both order and disorder moving from one state to another spontaneously [1]. In medicine one must then try to anticipate the dynamic processes of diseases in order to control the underlying disorder [2]. A systems approach is the continual re-evaluation of the changing perspectives of the processes being observed [3]. A systems approach then becomes an attitude by which to apply methods to study the processes. “We need not ask if nature is one but how she is one”-Henri Poincare [4].

Background

Medicine refers to the characterization of a disorder by a label, a diagnosis, and its management or treatment. The term medicine has been used on many different levels from molecular to physiological to organizational levels. What is common among these diverse levels is the use of the scientific method: The identification of a problem developing a hypothesis of cause, testing the hypothesis for validity then developing a plan for correction.

“In clinical medicine an algorithm for finding cause is to delineate the primary pattern of the disorder being investigated to find a matching secondary pattern to a known disease or diagnosis by consilience of the two patterns” [5]. This methodology is based on a model of clear cause and effect of acute diseases which was the basis for the early development of medicine. With the development of more chronic diseases this methodology has been problematic in diagnosis and treatment. Chronic diseases are characterized by being multi-factorial and a discernible pattern may not be identifiable. Therefore, the method for finding cause in chronic diseases will be dependent on a method that would accommodate complexity.

Purpose

The purpose of this paper is to present and substantiate a perspective of medicine that requires a shift in the conventional method of analyzing medicine to one that would be more dynamic in coping with the dynamic shifting from order and disorder. In developing this method concepts need to be determined and a language must be developed to be able to communicate clearly with the various experts in diverse domains. Medicine may be viewed as molecular to physiological to societal. This methodology will

be guided by the same philosophical concepts well described in the past in an attempt in re-introduce science into medicine.

Methods

“Science is built on facts as a house built of stone, but an accumulation of facts is no more a science than a heap of stones is a house” Henri Poincare [6]. Science must work with method. The central theme in the work of Charles Sanders Peirce is the “unified theory of the scientific method...the search for unity, a method of evolving inquiry, a continuity of inexhaustible and creative possibility. Reasoning which would permit the investigation to go on unimpeded and undiscouraged and not blocks the way of inquiry. The valuable truth is not the detached one, but the one that goes toward enlarging the system of what is already known” [7]. Peirce states the object of reasoning is to find out what we already know something else we do not know. The mode of reasoning he terms abductive inference is the foundation for the development of a hypothesis. Walton describes Peirce’s interpretation of the three types of inference as: “Deduction proves something must be Induction shows something is actually operative; Abduction merely suggests that something may be deduction being the strongest form of inference, abduction the weakest and inductive falling in between. Abduction provides the greatest possibilities of extending our ideas. The abductive process allows one to instinctively, intuitively and creatively collect our ideas through colligation into a pattern of relationships that might give further insight as to the underlying process. The hypothesis thus formed, although provisional, could now provide a better foundation from which further inquiry may be made. This method then allows one to extrapolate beyond our observations and becomes the strongest influence to extending understanding.

Walton describes Peirce’s example of the three forms of inference in the following example [8].

A. Deduction

Premise one: All the beans from this bag are white.

Premise two: These beans are from this bag.

Conclusion: These beans are White.

B. Induction

Premise one: These beans are from this bag.

Premise two: These beans are white.

Conclusion: All the beans from this bag are white.

C. Abduction

Premise one: All the beans from this bag are white.

Premise two: These beans are white.

Conclusion: These beans are from this bag.

Hickey and Roberts describe a form of the scientific method, the Solomonov Induction which could be used in the clinical setting [9]. It is based on three principles. Epicurus's concept of considering all the possibilities implies utilizing all the data. Occam's Razor concept of simplicity implies efficiency in decision making and Bayes' Theorem provides a means of updating ones impression with new experiences. Characterizing the problem using all of ones experiences, hypothesizing a most reasonable cause, implementing a test or therapeutic trial to make further observations then repeating this process would create a pattern and a heuristic or an intuitive experience. The scientific method described must also be applied to complex systems of chronic diseases. The intuitive process of abduction would allow one to seek out some semblance of order in the disorder or instability of a system thought to be at risk. Then once an ordered process is identified a more analytical method may be used to control the disorder and then proceeding again intuitively looking for another process within the disordered system at risk. This iterative process is described as the "systems engineering method" by Kossiakoff et al. Bacon describes his method of "establishing progressive stages of certainty...by a process of correction". Heuristic means "serving to discover". Polya describes heuristic as a form of induction where by general laws are discovered by observation of particular instances. It is an attempt to find regularity and coherence behind the observations. Frequently, they are described as "rules of thumb" or even parables by which some insight is stimulated. Use of heuristics in clinical medicine is common, efficient and based on the scientific method.

Implementation

The complexity of chronic diseases is comprised of numerous dynamically interactive processes. Therefore focusing on endpoints of pathology, diagnoses or syndromes may not lead to understanding cause. A focus on process and agents responsible for change may be not be as definitive as in the traditional model but may be more revealing in the understanding the causes of the underlying disorder. A primary focus should start with a search for inflammation which is the basis for most pathology then identifying common factors contributing to the inflammation. Other agents of process would be hormones, micronutrients and methylation which could all impact on inflammation and disorder. A common mechanism underlying inflammation is insulin resistance, an inappropriately elevated insulin level. This will set off a cascade of inflammation that would lead to a number of diseases if not controlled such as diabetes, cardiovascular diseases, obstructive sleep apnea as well as cancer.

One may intuitively identify insulin activity by observing glucose and insulin levels after fasting, different kinds of meals and correction of micronutrients deficiencies, hormones imbalance and physical activity. A more analytical approach that could now be used would be to use the quantitative technique, $QUICKI = 1 / \log \text{insulin} + \log \text{glucose}$ by Katz [7-13]. Then again, one would intuitively look for another common contributing process to focus on while constantly focusing and de-focusing stereoscopically to maintain perspective of the whole of complexity. This would be analogous to gluing a mitred wooden box together by rechecking continuously adjoining joints while working on one. At each stage some foundation is being laid down upon which more understanding will be built to ensure an enduring evolving inquiry. The clinical use of colligation may allow the use of constructs such as laboratory panels which would focus on physiologic function rather combinations of analyses with similar protocols such as panels for inflammation, glucose metabolism, hormonal balance, methylation and oxygen utilization. Other tests for physiologic resilience or robustness may also give perspectives of the ability to withstand stress, tissue healing and inflammatory responses.

Discussion

The current practice of medicine is based on the model of Evidence Based Medicine [EBM], guided diagnostically by the International Classification of Diseases [ICD], managed by a community standard of practice [SOC] and reimbursed by the Current Procedural Terminology [CPT]. EBM was launched in 1991 in Journal of the American Medical Association [JAMA] as the ideal way of making medical decisions based on large epidemiological studies and that there was no other alternative medicine than EBM. However, Hickey and Roberts state that "EBM has led to a rule based cookbook medicine with little regard for the individual patient. In decision theory one cannot apply averages of a population to an individual patient. ICD and the introduction of ICD-10 will be a tedious task of factoring down diseases and disorders into numerous categories without regard to cause. SOC is a legal term in tort law which forms the guideline from "scientific evidence" and collaboration of physicians to which one may be held accountable.

CPT developed by the American Medical Association provides the guidelines by which reimbursement is made. After submission of a claim this is then reviewed by the insurance industry or government regulators which then accept or reject the claim. All these guidelines and regulations have thus created a top down hierarchy which enforces central control and restricted the evolution of medicine into the realm of complexity in which it belongs.

Conclusion

If the construct of medicine in all of its dimensions can be reconfigured to a model of complexity then the processes currently at work may allow medicine to evolve from the bottom up accommodating all the growing information, the diverse interests and innovations into a universe of infinite options. What may emerge from this expanding universe would be an overgrowing of medicine of its current restrictions. Complexity

science the methodologies monism of a systems science medicine would then be the focus of resources and efforts. The patient now becomes more involved with the expanding options. The patient now becomes their own healer. Each physician-patient encounter creates a foundation for understanding. The short clinical trial is a Bayesian process that will update impressions. With the collection of individual clinical trials the experiences thus formed will be an emergence of intelligence from the bottom up, “wisdom of the crowds.” Clinical intuition is based on heuristics. The Epicurus concept to include all the possibilities necessitates openness and transparency in all perspectives and therefore due diligence in obtaining information. Occam’s Razor concept implies efficiency in decision making while keeping a “stereoscopic vision” of both the immediate process in focus as well as the overall response of the whole system. The Bayesian concept of updating one’s perspective with incoming new experiences allows one to work more intuitively with heuristics as one is constantly observing a dynamically changing system. The scientific method or the Solomonov Induction described would now provide a methodology to address the complexity in medicine and would override the blocking of inquiry by the current reductionism in medicine today. Beveridge describes a “transfer method” where “all scientific advances rest on a base of previous knowledge” [14]. This adaptation of previous knowledge may come from outside the domain of primary focus and therefore demands that scientists and physicians become more aware of developments in areas other than their own. This becomes the unifying mechanism of complexity.

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*Correspondence to:

Myles Suehiro MD, FAARFM
 Hawaii Institute for Health and Healing LLC, Hawaii,
 USA
 Tel: +1 808 372 511
 E-mail: msuehiromd@gmail.com