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The Immune System as A Model of Radiologic Practice

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Opinion

Mechanistic models of radiologic practice abound, but biologic perspectives are relatively scarce. For example, we devote considerable time to the potential of new devices, automated work-flow patterns, and machine learning to transform our work, while devoting relatively little attention to analogies from disciplines such as physiology and ecology. Yet biologic metaphors represent some of the most illuminating perspectives from which to understood current radiologic practice and visualize the future of the field. Consider one of the most remarkable of our physiologic systems, the immune system. By re-viewing how the immune system normally functions in protecting health and the numerous ways in which it can go awry, as in immunodeficiency and autoimmune diseases, we can gain deeper insights into the functions of a normal radiology practice, the many ways in which it can perform poorly, and strategies practices can employ to increase performance and reduce the risk of failure. We begin with a review of some of the most salient features of the human immune system.

Normal Immune Function

Broadly speaking, the immune system defends organisms against pathogens such as viruses, bacteria, and parasites. One of its most crucial functions is to distinguish between self and nonself that is, biological substances that are native to the organism and those that are foreign [1]. If the immune system fails to recognize foreign cells or mistake native cells, tissues, or organs for foreign, the consequences for health and life can prove dire. The immune system operates through two branches, the innate and adaptive systems. The innate immune system, whose paradigmatic response is inflammation, reacts more or less immediately in a non-specific fashion and confers no memory of any particular pathogen. The innate immune system is activated when receptors detect genetic components of pathogenic organisms or when injured cells send out signals [1]. For example, the complement system attacks molecules found on the surface of foreign cells, while a variety of injuries – mechanical, thermal, and chemical – may cause the release of molecules such as cytokines that summon white blood cells. Cytokines may also interfere with normal activities such as protein synthesis, without which a virus-infected cell cannot produce more viral particles [1].

By contrast, the adaptive immune system is involved in antibody production and takes time to mount a response to specific pathogens, while simultaneously producing an immunologic memory. The adaptive immune response is largely mediated by lymphocytes, with B cells functioning primarily in the humoral response and T cells in the cell-mediated response [1]. Once an immune response is activated, some of the B and T cells give rise to memory cells, which can persist throughout the organ-ism's lifetime. These memory cells enable the immune system to mount a much more rapid and po-tent response to antigens, should the pathogen be encountered again [1]. A variety of cell types and products are involved, including so-called killer and helper T cells, as well as antibodies synthesized by B cells.

Immunodeficiency

Immune deficiency disorders occur when one or more of the immune system's components is absent or fails to function normally. A variety of factors may be responsible, including age, the use of drugs such as corticosteroids, and malnutrition. HIV infection represents an example of immunodeficiency directly attributable to infection by a pathogen [2]. Over time, organisms and pathogens are always evolving to compete more effectively with one another, and HIV represents a case where a pathogen has at least temporarily gained the upper hand. Immunodeficiencies may be primary – due to an underlying immune system defect or secondary such as HIV infection [2]. An immunocompromised patient often runs greater risk of developing both conventional infections for which everyone is at risk, as well as opportunistic infections that occur on in states of immunodeficiency [2]. Any part of the immune system may fail, with predictable consequences. When B cells cannot make antibodies, the risk of conventional bacterial infections in increased. When T cells

are malfunctioning, the risk of viral, mycobacterial, and fungal infections are increased.

Autoimmunity

Autoimmune disorders result when the immune system mistakes healthy cells and tissues for foreign. Although the connotation of autoimmunity is pejorative, there is a sense in which autoimmune responses are not always harmful. For example, the immune system is involved in cancer surveillance, which requires it to recognize mutated native cells as foreign – a capability exploited by some recent immune therapies for cancer [3]. What may occur in many autoimmune disorders, including rheumatoid arthritis and autoimmune thyroiditis, is a loss of the ability to ignore "self [4]." It is noteworthy that the incidences of infectious disease and autoimmune disease appear to be inversely correlated. In other words, in parts of the world where populations have high rates of infectious disease there are low rates of autoimmune disease, while areas with low rates of infectious disease have higher rate of autoimmune disease. One possible explanation would be that some infectious organisms, such as parasites, may attenuate host immune response. Allergies and asthma are also less common where rates of infectious disease are high.

Radiologic Correlates

A well-functioning radiology practice resembles a well-functioning immune system in several respects. For one, to perform well, radiologists need to clearly understand what they do and who they are – and by extension, what and who they are not. If, for example, a radiologist is a consultant whose primary purpose is to enhance patient care, then regular interactions with other health professionals will play an essential role in maintaining the profession's health. By contrast, efforts to increase radiologic "productivity" by keeping such interactions to a minimum in order to enhance productivity are likely to take a toll on professionals who place a premium of collaboration and collegiality.

Radiologists do their work along different pathways, analogous to the divisions in the immune system. In some cases, like the innate immune system, work can be performed in a relatively generic fashion. For example, routine chest and bone radiographs can be interpreted without interaction with the referring health professional. Radiologists simply need to indicate whether pneumonia or fracture is present or not. I n other cases, akin to the adaptive immune response, the clinical setting or the radiologic findings warrant a more tailored response that requires further investigation or interaction with the patient or referring health professional. Good radiologists respect the difference. Failures to discern the appropriate type and level of attention to devote to each case can also lead to pathologies. Consider, for example, radiologists who work so quickly that they never under-stand clinical contexts in depth, interact meaningfully with referring health professionals, or find the fulfillment that working through a challenging case can provide. Alternatively, some radiologists may devote too much time and become so engrossed in each case that they cannot work efficiently and sometimes produce complex reports that do more to obscure rather than clarify diagnostic questions.

Numerous factors can lead to deficiencies in radiologic performance, thus hindering a radiology practice, just as immunodeficiency hinders the body. One such hinderance is an absence of passion. When radiologists cease to care about their work, it becomes impossible to sustain a high level of performance. People end up going through the motions, never deriving any personal fulfillment from their work. External factors may also be in play – for example, poor leadership, lack of collegiality, or a toxic workplace culture can all produce disaffected, disconnected, and demoralized radiologists, whose intrinsic motivation and resilience are certain to suffer. With equally pathologic consequences, some radiologists respond to their situations not too weakly but too strongly, analogous to an autoimmune disease. High levels of stress, at work or home, or a personality inclined to irascibility can cause minor irritations to flare into major conflagrations – making "a mountain of a mole hill." Such responses can be potentiated by prior episodes as frustration builds over time, to the point that radiologists find themselves saying "If so-and-so does such-and-such just one more time, I am going to. . .."

Prevention and Remedies

Radiology practices that know themselves stand a better chance of flourishing than those that do not. This means knowing not only the equipment, facilities, workflow, and personnel, but also un-derstanding both the current culture and the culture the practice is trying to build. A practice that seeks to maximize revenue is likely to look quite different from one that aims to promote personal and professional growth and fulfillment. If practices mistake one type of culture for another, they may discover that they are destroying themselves.

Just as the immune system consists of specialized component systems, good radiology practic-es need to do the same. Producing only a single type of immune cell or antibody would spell disaster for the health of an organism, and so would a practice culture that acts as though everyone should be the same. It will reap what it sows – a monoculture that lacks creativity, adaptability, and resilience. A thriving practice culture is to an important degree a diverse culture, one that not only tolerates but prizes the distinctive interests and capabilities of its members. As with the immune system, radiology practices need to foster a culture of proportion and bal-ance. The goal should not be to produce a perfect culture – an unachievable aspiration. In fact, minor nuisances and the like may actually play an important role in helping people to keep work and life in perspective, accurately discerning the difference between minor disappointments and irritations and full-fledged disasters. Keeping the little things

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in their place is a necessary feature of preparing to re-spond appropriately when some truly major challenges crop up.

Conclusion

it is true that many aspects of a radiology practice can be understood in mechanistic terms, and in some cases such metaphors may provide insights into the work and the people doing it. Yet biologic models also have a great deal to contribute, in large part because the most important resource of any radiologic practice is its people, who much more closely resemble living organisms than machines. By revisiting core biologic topics that many have not explored since medical school, radiologists can foster a deeper understanding of what a thriving radiology practice really should be.

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