Flow Patterns in the Abdominal Aorta: Relationships between Atherosclerosis and Aneurysm Formation

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Atherosclerosis and abdominal aortic aneurysms (AAA) share many common features including spatial localization that may be related to regions of disturbed flow. One of the basic paradigms in atherosclerosis is that areas of disturbed flow are associated with sites of initiation of atherosclerosis. Disturbed flow is a pro-inflammatory stimulus that modulates expression of many of the factors involved in the pathogenesis of atherosclerosis including reactive oxygen species and inflammatory proteins. Implicit in this mechanism is the assumption that the endothelium serves a pivotal role in the initiation of atherosclerosis.

AAA most commonly occur in older males and they are associated with risk factors that are similar (but clearly not identical) to those associated with atherosclerosis. In addition, many of the molecular and cellular mediators of atherosclerosis exhibit a significant degree of overlap between the two disease processes.

Therefore, we have hypothesized that disturbed flow in the abdominal aorta may be an important factor in the development of AAA. To this end, we have studied the flow patterns in mice and humans using computational approaches as well as phase contrast MR to identify the sites of disturbed flow and to further determine if the magnitude or site of disturbed flow correlates with inflammatory protein expression as well as the location and incidence of AAA formation. We have found that in animal models of AAA, the site of AAA formation correlates closely with regions of disturbed flow and resultant inflammatory protein expression. In the human studies, the most common site of AAA formation is in the infra-renal abdominal aorta, the most common site of AAA formation. Importantly, we examined differences in flow patterns in two clinical settings in which the incidence of AAA is either higher or lower. In the setting of traumatic amputation, it has been reported that AAA incidence is increased and we found in a human model of simulated amputation, that the magnitude of disturbed flow in the abdominal aorta was significantly increased. Conversely, in women, the incidence of AAA is lower and we have shown that the area of disturbed flow is markedly reduced. This may be a consequence of uterine artery flow.

In summary, we have developed data supportive of the concept that disturbed flow in the abdominal aorta is an important causal factor in the development of AAA. Differences in the incidence of AAA in some cases may be due to physiologic and pathophysiologic alterations in flow patterns in the abdominal aorta.