Why are arteries the size they are?

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SONES AND SHIREY (12) performed the first coronary artery angio-
gram by accident in 1958. While injecting contrast material for a
left ventricular angigram, the catheter slipped out of the ventricle
and into the right coronary artery. Sones immediately recognized
the advantage of visualizing the coronary artery lumen, and coronary angiography quickly developed (3, 12). Coronary an-
giography provided the needed diagnosis tool for new therapy,
coronary artery bypass surgery (4, 5). The most severe lesions
could now be quickly identified by the simple percent stenosis
measurement [100% × (normal artery diameter — minimal ste-
notic diameter)/normal artery diameter]. The percent stenosis
measurement is easy to perform, can be visually estimated, and
does not require quantification of the coronary artery size. This
measurement together with bypass surgery became the clinical
standard, which dramatically improved cardiovascular care (1).

Angiographically determined percent stenosis was the un-
challenged clinical standard for many years. The validity of the
percent stenosis measurement was not questioned despite
pathological examinations of human coronary arteries, which
revealed extensive disease, not limited to just the site of the
most obstructed portion of the artery (13). Later retrospective
examination of coronary angiograms showed that the lesion
associated with a subsequent myocardial infarction often was
not at the site of the most severe stenosis (10). The opinion of
the medical community finally changed with the advent of
quantitative coronary angiography and intravascular ultra-
sound, which unmistakably showed that once a severe coro-
nary artery stenosis occurred, generalized disease was present
throughout the vessel (7, 9).

If the normal size of the vessel can not be determined, how can the percent stenosis, even with its limitations, be calcu-
lated? Furthermore, how can diffuse coronary artery disease be
detected? In the Journal of Applied Physiology, the study by
Choy and Kassab (10) provides answers to these questions and
raises new questions. In a simple yet eloquent study, they
injected latex material into the coronary arteries of a pig and
compared the artery size to the mass of myocardium perfused by
that artery. They established a 3/8 power relationship
between artery size and myocardial mass. With new imaging
and measuring techniques, the coronary artery size and the
mass of myocardium perfused can be readily calculated. Using
the 3/8 power relationship will allow accurate determinations
of percent stenosis and diffuse coronary artery disease.

While the study by Choy and Kassab shows an empirical
relationship between artery size and myocardial mass, it does
not answer a more fundamental question why coronary arter-
ies, and for that matter arteries in general, are the size that they
are. What is the driving physiological principal determining
artery size? Is it a cost factor; the minimal arterial size required
to deliver blood with the lowest pressure drop (8, 14)? Does it
relate to the maximal oxygen carrying capacity of the blood?
What are the implications for coagulation? Is shear rate the key
to regulating vessel size? The measured shear rates at the
endothelial surface of all vessels are remarkably similar.
O’Keefe et al. (11) measured coronary dimensions in human
hearts hypertrophied from valvular heart disease and demon-
strated a linear relationship between cross-sectional area of the
artery and the myocardial mass supplied by the artery. If,
however, endothelial cells regulate deformation rather than shear
stress, then circumferential strain may be the key factor (6).

So, why are coronary arteries the size that they are? Al-
though this is seemingly a purely academic question, the
answer will provide valuable clinical insight, possibly leading to
novel diagnosis approaches and new therapies. The study by
Choy and Kassab (2) has provided valuable information about
coronary artery size and, hopefully, will stimulate even more
research in this area.

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