

This Week's Citation Classic™

Page D L, Caulfield J B, Kastor J A, DeSanctis R W & Sanders C A. Myocardial changes associated with cardiogenic shock. *N. Engl. J. Med.* 285:133-7, 1971.

[Depts. Pathology and Medicine, Massachusetts General Hosp. and Harvard Medical Sch., Boston, MA]

Patients dying with cardiogenic shock secondary to myocardial infarction had necrosis of at least 40 percent of the left ventricular myocardium demonstrated at necropsy. All patients dying with myocardial infarction without shock (with one exception) had lost 35 percent or less of the left ventricular muscle. [The SC® indicates that this paper has been cited in over 410 publications since 1971.]

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"This paper was the result of a collaborative effort among basic scientists, cardiologists, and anatomic pathologists. The project had its inception in the establishment of the Myocardial Infarction Research Unit at the Massachusetts General Hospital in 1967. This sponsored program was begun at the initiation of the National Heart Institute in order to foster research in myocardial infarction. The original proposal, with Charles Sanders as the principal investigator, included a request to study the syndrome of cardiogenic shock. This portion of the proposal was written by J.B. Caulfield, who had described the ultrastructure of ischemic myocardium in 1959.¹ As a resident in pathology, I performed the necropsy examinations on these patients so that they might all be done in a uniform and prospective manner. With the considerable aid of a research technician and support from a superb departmental photography unit, the studies could be done with care using a technique developed by D.B. Hackel of Duke University.²

"Close correlation between anatomic

findings and clinical events was guaranteed by frequent meetings between cardiologists and pathologists. Our demonstration that anatomic events within the coronary arterial tree were the same in patients dying of myocardial infarction with and without cardiogenic shock, combined with our demonstration that the quantity of injured myocardium was different, led us to conclude that loss of more than approximately 40 percent of the left ventricular myocardium produced irreversible pump failure. We also demonstrated that the pattern of myocardial injury in shock secondary to noncardiac events was quite different from that found in the other patients, completing our attempt at understanding the correlation of clinical, coronary arterial, and myocardial events.

"Our conclusions were first published in 1970³ and were supported almost simultaneously by a British study,⁴ and confirmed by a similarly conducted study reported from Cornell University in 1973.⁵

"The demonstration that the quantity of myocardial necrosis is central to the production of cardiogenic shock has led to a great deal of study,⁶ much of it aimed at preservation of ischemic and sublethally damaged myocardium.

"This study was also important in demonstrating the heterogeneity of clinical and pathophysiologic events in ischemic heart disease. Caulfield *et al.* later suggested therapeutic implications of rapid *versus* delayed onset of shock after myocardial infarction.⁷ These studies, based on data obtained from clinicopathologic correlation at time of autopsy, illustrate the current usefulness of such studies. Clinically relevant observations and new concepts are still coming from the autopsy room as evidenced by the interest in infarct extension as opposed to infarct expansion as proposed by Hutchins and Bulkley."⁸

1. **Caulfield J & Kliansky B.** Myocardial ischemia and early infarction: an electron microscopic study. *Amer. J. Pathol.* 35:489-535. 1959. (Cited 175 times since 1959.)
2. **Hackel D B.** A technic to estimate the quantity of infarcted myocardium post mortem. *Amer. J. Clin. Pathol.* 61:242-6. 1974.
3. **Page D L, Caulfield J B, Kastor J A, DeSanctis R W & Sanders C A.** Myocardial changes associated with cardiogenic shock. *Proceedings of the Second Annual Meeting. International Study Group for Research in Cardiac Metabolism.* Pavia, Italy. Editrice Fucc. Fusi. 1970. p. 265-81.
4. **Hamarayon C, Bennett M A, Pentecost B L & Brewer D B.** Quantitative study of infarcted myocardium in cardiogenic shock. *Brit. Heart J.* 32:728-32. 1970. (Cited 180 times.)
5. **Alonso D R, Scheldt S, Post M & Killip T.** Pathophysiology of cardiogenic shock. *Circulation* 48:588-96. 1973. (Cited 135 times.)
6. **Reimer K A.** Myocardial infarct size. *Arch. Pathol. Lab. Med.* 104:225-30. 1980.
7. **Caulfield J B, Leinbach R & Gold H.** The relationship of myocardial infarct size and prognosis. *Circulation* 53(Suppl. 1):141-4. 1976.
8. **Bulkier B & Hutchins G.** Infarct expansion versus extension: two different complications of acute myocardial infarction. *Amer. J. Cardiol.* 41:1127-32. 1978.