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The blood supply of the vermiform appendix in Nigerians

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There is no general agreement in the literature about the arterial blood supply of the vermiform appendix. Published papers and standard text-books contain differing statements about the number of arteries which supply this organ and also about the immediate derivation of these vessels (Table 1). Some authoritative sources such as Koster & Weintrob (1928), Bruce, Walmsley & Ross (1964), and Grant & Basmajian (1965) state that the appendix is supplied by only one artery; but other workers (Shah & Shah, 1946; and Wakeley, Harmer & Taylor, 1960) claim that it is supplied by more than one vessel. Little information is available in the literature about the distribution and pattern of branching of the appendicular arteries. In view of the discrepancies in the literature about the anatomy of the vascular supply of the appendix and the apparent rarity of appendicitis among Africans (Short, 1946; Kerr, 1957; Bailey & Love, 1965), this investigation was undertaken to determine the origin, patterns of branching and anastomoses of the appendicular arteries in Nigerians. Previous studies on the blood supply of the appendix were carried out either as part of routine dissections of injected cadavers or by the direct injection of dye into the main appendicular artery. With these methods of study there might be difficulty in defining clearly the exact origin of the main appendicular artery, and accessory vessels to the appendix might be missed. In this study, the arterial supply of the appendix was demonstrated by injecting a suspension of barium sulphate into the superior mesenteric artery, and the pattern of distribution was studied by radiological and histological examinations.

MATERIAL AND METHODS

One hundred cadavers were selected from the mortuary of the University College Hospital, Ibadan, excluding those patients in which death was due to intra-abdominal catastrophies. Causes of death included tetanus, meningitis, kwashiorkor, chronic nephritis, congestive cardiac failure, reticulum cell sarcoma, carcinoma of liver and lung.

The superior mesenteric artery was injected in 48 female subjects of ages varying from 7 months to 65 years, and 52 male subjects whose ages ranged from 1 month to 67 years. Over 60 % of the subjects studied were under 30 years of age (Fig. 1). Between 4 and 72 h after death the superior mesenteric artery was freed in front of the third part of duodenum. A Gullmo self-retaining catheter (Gullmo, 1956) was tied in to prevent leakage of the injection mass. A milky suspension of 600 g of barium sulphate in 500 ml of tap water was obtained by mechanical mixing with a Waring blender. Between 5 and 30 ml of this mixture were injected by gentle manual pressure, occasionally assisted by milking along the ileocolic artery.

After completing the injection, ligatures were tied around the ileocolic artery at its

Table 1. *Blood supply to the appendix*

Author	Year	Place of study	Method of study	No. of specimens	Race of subjects	Sex M	Sex F	Ages (years)	Source of appendicular supply	Anastomoses Arterial	Anastomoses Arteriolar	Anastomoses Capillary
Smith	1911	New York Foundling Hospital	Routine dissection	1050	—	510	540	Less than 3/12	Anterior branch of ileocolic artery	—	—	—
Koster & Weintrob	1928	Brooklyn	Injection studies	100	—	—		10–70	Ileocolic artery	—	Present	—
Shah & Shah	1946	India	Routine dissection	60	Indians	—		Adults	Anterior caecal branch; posterior caecal branch	—	—	—
Hollinshead*	1956	—	—	—	—	—		—	Ileocolic artery and branches	Present	—	—
Wakeley, Harmer & Taylor*	1960	—	—	—	—	—		—	Posterior ileocaecal branch of ileocolic artery	—	—	—
Davies & Davies*	1962	—	—	—	—	—		—	Inferior branch of ileocolic artery	Present	—	—
Bruce, Walmsley & Ross*	1964	—	—	—	—	—		—	Ileocolic artery	Absent	—	—
Davis*	1964	—	—	—	—	—		—	Ileocolic artery	—	—	—
Bailey & Love*	1965	—	—	—	—	—		—	Ileocolic artery Post. caecal branch	—	—	—
Grant & Basmajian*	1965	—	—	—	—	—		—	Descending branch of ileocolic artery	—	—	—
Robinson*	1965	—	—	—	—	—		—	Ileocolic artery	Absent	—	—

* Text-books.

origin, the terminal ileum 10 cm proximal to the ileocoecal valve and ascending colon 10 cm distal to the caecum. The whole specimen was removed, examined by naked eye and X-rayed from anterior and posterior views. The appendix was then divided at the caeco-appendicular junction and fixed in formalin. Histological sections taken from the base, midportion and tip of each appendix were stained with haematoxylin and eosin.

Definitions

The main appendicular artery is defined as one which runs in the crescentic fold of the meso-appendix to the tip of the appendix; and the accessory appendicular artery as one which supplies other parts of the appendix except the tip.

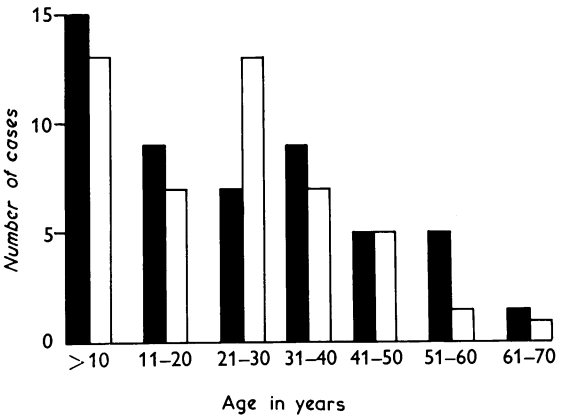


Fig. 1. Age and sex distribution of 100 cadavers studied. ■, ♂; □, ♀.

RESULTS

Ileocolic artery and its branches

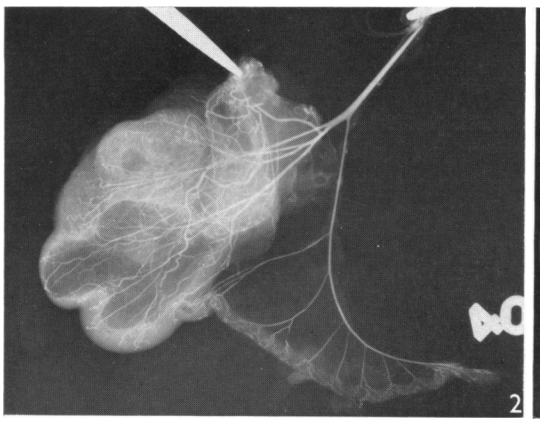
In this series the artery was invariably the lowest branch of the superior mesenteric artery. In eighty-four bodies it remained single, but in sixteen it divided into medial and lateral branches of equal calibre soon after its origin. Branches of the single or paired vessels supplied the colon, caecum and terminal ileum. No significant variants were found apart from the appendicular vessels. The blood supply of the organ was similar in both sexes.

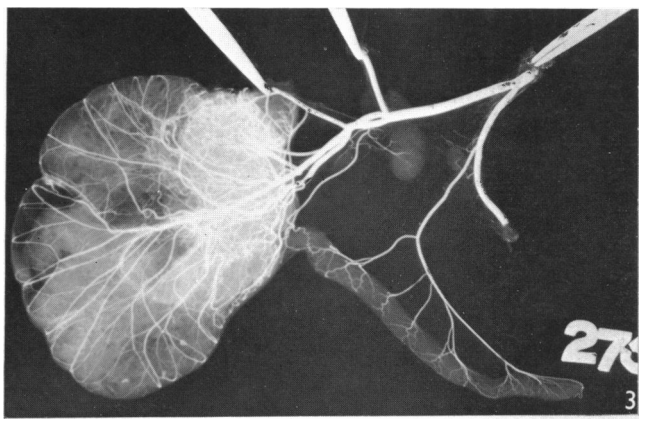
The main appendicular arteries

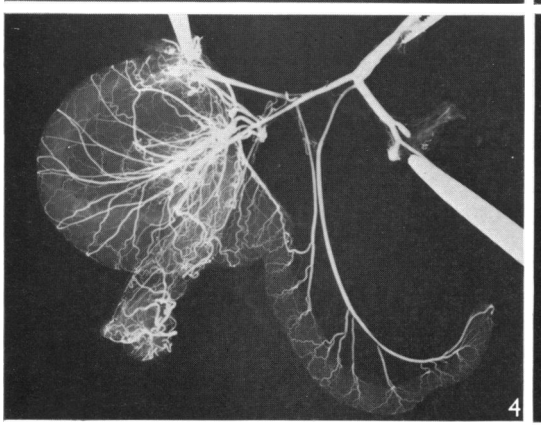
The appendix received its main artery from a variety of sources directly or indirectly from the ileocolic artery (Table 2). The main appendicular artery came off the ileocolic artery in 50 bodies and in 16 where the ileocolic artery was double the medial branch gave main appendicular arteries in 13 cadavers and the lateral in none.

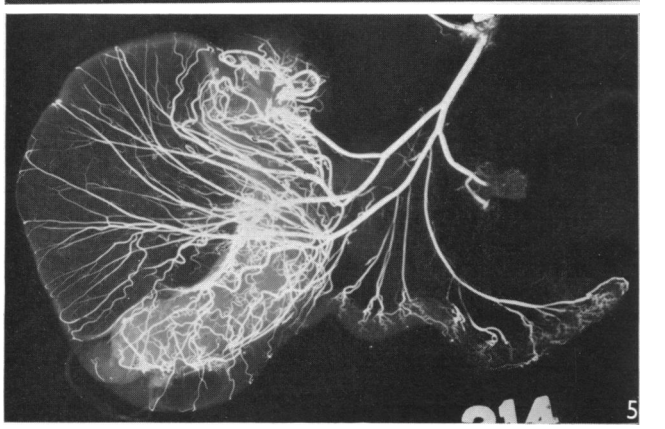
The main appendicular artery pursued an arcuate course in the crescentic fold of the mesoappendix, approaching the appendix as it extended to the tip. The artery terminated at the tip in ninety-nine cadavers, but in one it turned round the tip and

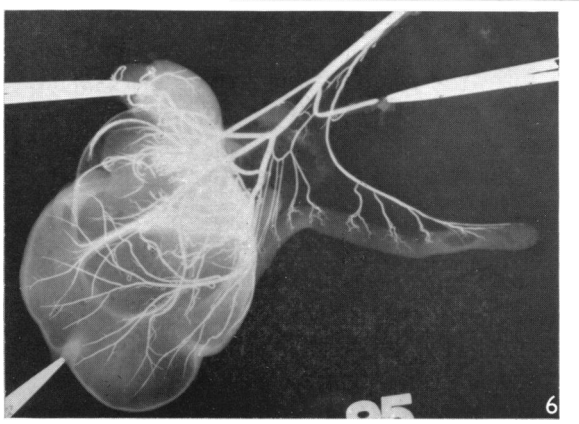
continued on the free border of the organ for a distance of 2 cm. The main appendicular artery while in the free edge of the mesoappendix gave off a number of branches (Table 3), which were parallel to and approximately equidistant from one another. All primary branches divided into two encircling branches on reaching the appendix. In











those cases in which the appendix received more than one arterial blood supply the estimated portions of the appendix supplied by the main appendicular artery are as shown in Table 4.

Accessory appendicular arteries

Eighty out of 100 cadavers received an additional supply from accessory vessels which ranged in number from one to nine. These accessory vessels were derived from several sources as shown in Table 5. The source of the accessory arteries derived from arterial loops is shown in Table 6 (see Figs. 2–6). Each accessory artery divided near the hilum of the appendix into primary branches which passed on either side of the appendix.

Table 2. *Origin of main appendicular arteries* (100 *specimens*)

Source	Sex		No. of specimens
	M	F	
Ileocolic artery	22	28	50
Ileal branch	16	16	32
Med. ileocolic	10	3	13
Ascending colic branch	2	1	3
Anterior caecal branch	1	—	1
Arterial loop between ascending colic and ileal branches	1	—	1
Total	52	48	100

Anastomoses at arterial and arteriolar levels

In 36 cadavers there were arterial anastomoses in the meso-appendix. Of these, 23 exhibited arterial loops formed by branches of the ileocolic artery (Table 6). In 13 there were anastomotic connexions between branches of the appendicular arteries. In all the 100 appendices, branches of the appendicular arteries divided into fine ramifications on the walls of the appendix and anastomosed freely. The terminal part of the main appendicular artery supplying the tip was usually an end artery with no anastomosis with other branches.

Fig. 2. The main appendicular artery arises from the ileocolic artery. It runs to the tip, supplying eight branches to the base and whole length of the appendix.

Fig. 3. The main appendicular artery arises from the ileal branch of the ileocolic artery. It runs to the tip, supplying six branches to the distal three-quarters of the appendix. The base and proximal quarter are supplied by an accessory artery from the ileocolic artery.

Fig. 4. The main appendicular artery arises from the ileal branch of the ileocolic artery, supplies four branches to the distal half of the appendix and terminates at the tip. An accessory artery from the ileocolic artery sends branches to the base and proximal quarter of the appendix, and a recurrent branch to the caecum.

Fig. 5. The main appendicular artery arises from the ileocolic artery, supplying four branches to the distal half of the appendix. Three accessory arteries from the terminal part of the ileocolic artery supply the base and proximal half.

Fig. 6. The main appendicular artery arises from the ileocolic artery, supplies four branches to the distal half of the appendix, and terminates at the tip. A communicating 'loop' exists between the terminal part of the ileocolic artery and the ileal branch. From this 'loop' arises four accessory arteries to supply the base and proximal half of the appendix.

Table 3. *Branches of main appendicular artery*

Branches	No. of specimens	Branches	No. of specimens
1	1	6	24
2	1	7	14
3	6	8	11
4	15	9	9
5	15	10	4
			Total 100

Table 4. *Portions of the appendix supplied the main appendicular artery in eighty specimens*

Areas supplied	No. of specimens	Percentage
Whole length	7	8·7
Distal three-quarters	43	53·7
Distal half	21	26·3
Distal quarter	9	11·3

Table 5. *Source of accessory vessels (eighty specimens)*

	No. of accessory arteries									
Source	1	2	3	4	5	6	7	8	9	Total
Ileocolic	25	9	—	—	1	—	—	—	—	35
Lat. ileocolic	2	1	1	—	—	—	—	—	—	4
Med. ileocolic	2	1	1	—	—	—	—	—	—	4
Ileal branch	3	—	—	—	—	—	—	—	—	3
Post. caecal	7	2	2	1	—	—	—	—	—	12
Ant. caecal	4	2	—	1	1	—	—	—	—	8
Ascending colic	3	—	—	—	—	—	—	—	—	3
Arterial loop	6	5	3	3	3	1	—	1	1	23
Total	52	20	7	5	5	1	—	1	1	92*

* Accessory appendicular arteries were derived in some specimens from more than one source.

Table 6. *Accessory appendicular arteries from arterial loop formations*

Arterial vessels involved	No. of specimens
Main appendicular artery	
Anterior caecal branch	4
Ileocolic artery	4
Posterior caecal branch	4
Ascending colic branch	3
Lat. ileocolic	2
Ileocolic artery (an ileal branch)	3
Med. ileocolic (anterior caecal branch)	1
Ileal branch (anterior caecal branch)	1
Ileal branch (ascending colic branch)	1
Total	23

Histology

The barium sulphate suspension made it easy to study the distribution of arterial blood vessels in the histological sections of the appendix. Each branch on reaching the hilum of the appendix divided into two or more branches before penetrating the coats of the appendix. The encircling branches divided after a short distance into two plexuses, namely an outer and an inner plexus. The outer plexus was made up of vessels which run in the serosa and were of smaller calibre than those of the inner plexus. The inner plexus was made of larger calibre vessels which run in the outer part of the submucosa. The blood vessels gained access to the submucosa by passing through openings in the muscular layer. It was noted that there were fewer blood vessels at the tip of the appendix in both the outer and inner plexuses.

DISCUSSION

The method described in this study is a simple one and can be used in the study of arterial blood supply of other organs or viscus. The suspension clearly outlines the vessel and its branches; and permanent records can be kept by taking radiological pictures of the specimens.

Injection of the superior mesenteric artery with barium sulphate suspension in the study of arterial blood supply to the appendix is likely to give more information about the derivation and distribution of the total blood supply of the appendix than was available in older studies. Koster & Weintrob (1928) in their study of 100 appendices, normal and pathological, injected the main appendicular artery directly with barium sulphate. Their results did not give any information about the origin of the main appendicular artery nor the existence of accessory appendicular arteries. The widely quoted work of Shah & Shah (1946), although drawing attention to the presence of accessory appendicular arteries, did not report the variations in the origin of the main appendicular and accessory arteries as recorded in this study (Tables 2, 5 and 6).

This technique has its drawbacks, one of these being leakage or spillage of the suspension from the artery into the surrounding tissue. Such leakage will undoubtedly make the study of the arterial architecture difficult and inaccurate. While it is possible to study the origin and distribution of the appendicular arteries, arterial and arteriolar anastomoses, it has not been possible to study capillary anastomoses in the appendix by this method.

There is no unanimity in the literature about the origin of the main appendicular artery. Some workers claim that it arises solely from the ileocolic artery (Koster & Weintrob, 1928; Bruce *et al.* 1964; Robinson, 1965); others claim that it comes off one of the branches of the ileocolic artery (Smith, 1911; Hollinshead, 1956; Davies & Davies, 1962). Beaton, Anson, Swigart & Johnson (1953) in their study of 200 specimens noted that the main appendicular artery arose in 48·5 % of cases from the ileocolic artery, in 35·0 % from the ileal branch and in 5·0 % from the posterior caecal branch of the ileocolic artery. The findings in the present study relating to the origin of the main appendicular artery are basically in agreement with those of Beaton and his co-workers.

The majority of those workers who have noted the presence of accessory appendicular arteries claim that these arteries invariably arise from the anterior or posterior caecal artery. Kelly & Hurdon (1905) remarked that in 66·0 % of appendices studied the main appendicular artery supplied the distal three-quarters of the appendix, while an accessory appendicular artery supplied the proximal fourth. Shah & Shah (1946) showed that in 30·0 % of appendices studied the appendix received two branches from either the anterior or posterior caecal artery or one branch from each of these. Schaeffer (1953) stated that in addition to the main appendicular artery which supplied the whole length of the appendix there is an accessory artery to the caeco-appendicular junction and that both branches arise from the posterior caecal branch of the ileocolic artery. In this study, accessory arteries were encountered more frequently (80 %) than had been previously reported, and they derived their origin from a variety of sources (Table 5).

It is pertinent to draw attention to the high frequency of arterial anastomoses noted in this study. These anastomoses occurred between the appendicular arteries and other branches of the ileocolic artery, and also between branches of the main and accessory appendicular arteries. If the main appendicular artery becomes occluded or diseased these vascular connexions will probably take over the local circulation in the appendix. The fact that the majority of previous authors (Table 1) have not mentioned these anastomoses might be attributed to their methods of study of the arterial supply of the appendix. On the other hand, it is possible that the presence of these arterial anastomoses represents a racial difference and may be one of the factors responsible for the recorded rarity of appendicitis among Africans (Short, 1946; Burkitt, 1952). It should be noted that Nigerians do not enjoy an absolute immunity from appendicitis (Solanke, 1965; Omo-Dare & Thomas, 1966).

SUMMARY

The arterial blood supply to the appendix was studied after cannulating and injecting the superior mesenteric artery with barium sulphate suspension. One hundred appendices of Nigerian cadavers were treated in this way. Contrary to standard teaching, there was variation in the pattern of arterial blood supply to the appendix. In 80 % of appendices in this series, more than one appendicular artery was demonstrated. In one-third of appendices, arterial anastomoses were found in the meso-appendix. In most, the main appendicular artery ended at the tip of the appendix as an end artery. The tip was poorly supplied as compared with the rest of the appendix. The presence of the dual blood supply to the appendix and the arterial anastomoses in the meso-appendix may partly explain the recorded rarity of appendicitis in Africans.

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