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Cerebral Complications Following Ligation of the Carotid Artery.

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CEREBRAL COMPLICATIONS FOLLOWING LIGATION OF THE
CAROTID ARTERY.

BY

Robert W. Lockhart

A Thesis in Biology Submitted in Partial Fulfillment of
the Requirements for the Degree of

Bachelor of Science

in the

Division of Arts and Sciences

of the

Prairie View State Normal and Industrial College

Prairie View, Texas

August 1939

DEDICATED TO
My Mother and Father.

CONTENTS

	Page
I. Introduction	1
II. Procedure	2
III. Observations and Results	4
IV. Discussion	4
V. Summary and Conclusions	4
VI. Bibliography	11

ACKNOWLEDGEMENT

The writer wishes to express his sincere appreciation to Mr. W. M. Booker, Head of the Biology Department, for his aid, interest and many helpful criticisms during the investigation.

INTRODUCTION

For a considerable period of time, ligation of the carotid artery has been used as a therapeutic measure for a variety of serious cranio-cerebral conditions. Originally it was used as an emergency measure in an effort to control severe hemorrhage following lacerations of the large vessels of the neck and head. During the middle years of the century it was

CONTENTS

	Page
I. Introduction	1
II. Procedure.....	2
III. Observations and Results.....	4
IV. Discussion.....	6
V. Summary and Conclusion.....	10
VI. Bibliography.....	11

The seriousness of carotid ligation was stressed by Pillemer and Trass,⁵ who concluded that in from twenty to twenty to twenty-five percent of patients who survive the operation cerebral complications develop.

On the basis of controversies on this problem and the interest manifested in the writer an interest was stimulated to re-investigate the effects of carotid ligation on brain tissue.

INTRODUCTION

For a considerable period of time, ligation of the carotid artery has been used as a therapeutic measure for a variety of serious cranio-cerebral conditions⁵. Originally it was used as an emergency measure in an effort to control severe hemorrhage following lacerations of the large vessels of the neck and head. During the middle years of the nineteenth century it was attempted for the purpose of relieving cerebral disorders, which were then incurable. However, the operation was discarded because the mortality was high and the permanent symptoms of recovered patients serious⁵.

In the past thirty years, with the increasing safety of surgical measures, the procedure has been reintroduced.

The seriousness of carotid ligation was stressed by Pilcher and Thuss,⁵ who concluded that in from twenty to twenty to twenty-five percent of patients who survive the operation cerebral complications develop.

On the basis of controversies on this problem and the interest manifested in the writer an interest was stimulated to re-investigate the effects of carotid ligation on brain tissue.

Procedure

The problem was attacked from two angles; first, the ligation of only the right common carotid artery, and second, the ligation of both common carotids.

The first operation was performed June 11, using a puppy as subject. The subject was anesthetized with ether, and secured to the operating table ventral side up. An incision was made on the neck about an inch below the larynx and extending about one and one-half inches posteriorly. The right carotid artery was located on the left and parallel to the trachea. The vagus nerve lying in the carotid sheath, alongside the carotid artery, was separated from the carotid and a ligature of cotton thread put on the carotid, completely cutting off the blood flow through this vessel. The animal was then sutured and allowed to recover from the anesthetic.

The exteroceptive reflexes and behavior of the animal were checked daily.

About twenty-five days after the first operation on this subject, the animal was again anesthetized and an incision made on the neck, as in the first operation the animal. The ligature was examined on the right carotid to see if it (ligature) had

OBSERVATIONS AND RESULTS

Dissolved or if there was any escape of blood through this artery.

This subject was allowed to live and observations were made daily until July 28, when the animal was killed and an autopsy performed on the brain.

The next operation was performed on a cat. The same general procedures were followed as in the preceding operation, except that both common carotids were ligated in this animal. At frequent intervals observations were made on this animal until death, about thirty-six hours after the operation.

The third operation was performed on a cat. The same general procedures were used as in the operation on the second animal. After the death of this animal, about thirty-six hours the operation, an autopsy was performed on the brain.

After this second operation, there still remained in the puppy a nervousness and rigidity of the hind limbs, which lasted throughout his life.

About the sixth week after the first operation there began to show an inclination of the head to the right side. These were the only signs of abnormality. A daily test of the exteroceptive reflexes gave normal results.

On July 28 the carotids were examined. This examination revealed a marked distention in size of the ligated carotid.

OBSERVATIONS AND RESULTS

SUBJECT 1-(puppy)

There were no noticeable signs of unnatural behavior until three weeks after the operation. The animal seemed a little more nervous than normal puppies of the same age and exhibited a partial stiffening, especially of the hind limbs. Other than this there were no differences of behavior between this puppy and normal puppies.

Twenty-five days after the first operation, an examination of the ligature on the carotid revealed the blood flow to be still obstructed in this vessel. There was no noticeable change in the artery. A comparison of the two carotids showed no difference between the two, other than the ligature on the right carotid.

After this second operation, there still remained in the puppy a nervousness and rigidity of the hind limbs, which lasted throughout his life.

About the sixth week after the first operation there began to show an inclination of the head to the right side. These were the only signs of abnormality. A daily test of the exteroceptive reflexes gave normal results.

On July 28 the carotids were examined. This examination revealed a marked diminution in size of the ligated carotid.

ALIMENTATION

It showed a pale color and signs of degeneration.

The left carotid(unligated) showed an abnormal distention and high pressure.

After this examination the animal was killed and the brain removed. Upon examining the brain there could be seen a slight degeneration of tissue of the right anterior lobe of the cerebrum.

SUBJECT 2-(Cat)

After ligation of both carotids in this animal there were at once observed signs of nervousness. The reflexes were normal. After thirty-six hours death resulted.

SUBJECT 3(Cat)

After ligation of both carotids in this animal there at once observed signs of nervousness. The exteroceptive reflexes were normal. After thirty-six hours death resulted. This animal showed the same symptoms as the second subject.

An examination of the brain revealed a paleness, significant of tissue deprived of blood.

Deprivation of blood to the brain would also cause acute effects, evidencing themselves in slow response and a lower or below ordinary intelligence, provided deprivation is

DISCUSSION

The brain is supplied with blood by the cross connections of the internal and external carotids and vertebrals. This arrangement is known as the Circle of Willis. The arrangement of the cross connections is of such nature that the interruption of one source will not completely cut off the blood supply to the brain¹.

Howell² says, "in some animals, the dog, one can ligate both internal carotids and both vertebrals without causing unconsciousness or death of the animal". Under these conditions a collateral circulation must be brought into play through the anastomoses of the spinal arteries.

Although this condition would not cause unconsciousness or death of the animal, this continued deprivation of blood, and consequently deprivation of oxygen and tissue food in the arterial blood, would cause a degeneration in the tissue comprising the brain. This is clearly seen by the fact that the brain has a very high rate of metabolism which would demand great supply of blood of an average of 50 c.c. per minute.

Deprivation of blood to the brain would also cause acute effects, evidencing themselves in slow response and a below par or below ordinary intelligence, provided deprivation is

great enough.

Fetterman and Pritchard⁵ gave an account of a case of a man in whom profuse hemorrhage of the left nostril was the cause for the ligation of both the external and internal carotids on the left side. Two hours after this procedure there developed loss of the limbs on the left side of the body with difficulty of speech and swallowing. Thereafter the clinical course was that of chronic disease. He was not able to use his arm or leg, he could not express himself and three months later convulsions developed. After about seven months later he was examined. He had become weak and lost weight for four months. There had been no return of function in the extremities and atrophy of the right shoulder girdle had developed. There was an improvement in speech and less frequent convulsions. Several months later the man died from acute peritonitis, which was independent of the major neurologic disorder. An autopsy of the brain revealed the left lateral ventricle to be much larger than the right. In the Sylvian artery there was an area of necrosis which extended forward almost to the left frontal lobe and involved three frontal convolutions; posteriorly it extended to the occipital lobe. Posteriorly the region of the supramarginal gyrus was

involved. The lumen of the left internal carotid was obliterated.

From this case we may reasonably conclude that a sudden loss of circulation resulted in cerebral anemia and subsequent encephalomalacia.

G.M.Dorrance⁵ in a report dealing with ligation of the great vessels of the neck, mentions four possible mechanisms to explain cerebral catastrophies following the procedure.

1- Anomalies and variations in the Circle of Willis.

Cerebral anemia resulting from an occlusion of a large vessel raised the question of the compensatory efficiency of the anastomotic pathways of the Circle of Willis.

Theoretically one might assume that no such anemia would result if the collateral supply were adequate.

Animal experiments tend to show that there is a fairly free anastomosis in the brain. Whereas there is anastomotic continuity between the vessels, the angularity and difference in the size of the vessels might be responsible for a reduced flow of blood in certain areas of the brain.

2- Thrombosis and embolism.

Thrombosis and embolism from the ligated side is another possibility. In some cases a progressive advance of a clot

SUMMARY AND CONCLUSIONS

along the occluding vessel might be responsible for anemia of the cortex.

3- Stimulation of the cervical sympathetic trunks.

A rise in intravascular tension or compression of the sinus causes vagal impulses which reflexly may produce slowing of the heart, fall in blood pressure or direct sinocerebral impulses leading a reduction in the cortical flow of blood.

The contributing physiological factors were the severe anemia and the low generalized blood pressure.

the occlusion of the right carotid.

2- A ligation of one carotid, cutting off a considerable amount of blood needed, caused at least a period of respiratory anemia of the brain in which there was endophthalmia set up. This period probably lasted until collateral circulation compensated for the impairment of one of the vessels.

3- The ligation of both carotids set up a continued anemia of the brain. The collateral circulation in the vertebrals was not enough to compensate for the impairment of both carotids. This incapacitation of the brain consequently resulted in the death of the animal. This would also account for the stupid condition of the animal.

SUMMARY AND CONCLUSION

In view of the data presented on this experiment we may arrive at the following conclusions:

1- Diminution in size of the right carotid was the result of disuse and deprivation of blood in the artery itself. This decrease in size was a degeneration of the tissue of the vessel.

The increase in size of the right was the result of a greater pressure in that vessel in an attempt to compensate for the occlusion of the right carotid.

2- A ligation of one carotid, cutting off a considerable amount of blood needed, caused at least a period of temporary anemia of the brain in which there was encephalomalacia set up. This period probably lasted until collateral circulation compensated for the impairment of one of the vessels.

3- The ligation of both carotids set up a continued anemia of the brain. The collateral circulation in the vertebrals was not enough to compensate for the impairment of both carotids. This incapacitation of the brain consequently resulted in the death of the animal. This would also account for the stupid condition of the animal.

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