Outcome of Endovascular Treatment of Cerebral Arteriovenous Malformations with Ethylene Vinyl Alcohol Coploymer

Thesis

Submitted For Partial Fulfillment of the Doctoral Degree
in **Neurosurgery**

By

Abd Allah Mouhammed Maher Salem
M.B., B.Ch. MSc
Faculty Of Medicine-Ain Shams University

Under Supervision of

Prof. Dr. / Husein El Sayed Mohram
Professor of Neurosurgery
Faculty of Medicine – Ain Shams University

Prof. Dr. / Mohamed Alaa EL Dein Habib
Professor of Neurosurgery
Faculty of Medicine – Ain Shams University

Dr. / Sherif Hashem Mourad
Assistant Professor of Neurosurgery
Faculty of Medicine – Ain Shams University

Dr. / Ahmed Hassan Abo Zeid
Assistant Professor of Neurosurgery
Faculty of Medicine – Ain Shams University

Faculty of Medicine
Ain Shams University

2018

Acknowledgment

First and foremost, I feel always indebted to **ALLAH**, *the Most Kind and Most Merciful.*

I'd like to express my respectful thanks and profound gratitude to Prof. Dr. / Husein El Sayed Mohram, *Professor of Neurosurgery Faculty of Medicine – Ain Shams University for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

I am also delighted to express my deepest gratitude and thanks to Prof. Dr. / Mohamed Alaa EL Dein Habib, *Professor of Neurosurgery Faculty of Medicine – Ain Shams University, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

I am deeply thankful to Dr. / Sherif Hashem Mourad, *Assistant Professor of Neurosurgery Faculty of Medicine – Ain Shams University, for her great help, active participation and guidance.*

I wish to introduce my deep respect and thanks to Dr. / Ahmed Hassan Abo Zeid, *Assistant Professor of Neurosurgery Faculty of Medicine – Ain Shams University, for her kindness, supervision and cooperation in this work.*

Abd Allah Mouhammed Maher Salem

List of Contents

Title	Page No.

List of Tables

List of Figures

Fig. No.	Title	Page No.

List of Figures Cont...

Fig. No.	Title	Page No.

List of Figures Cont...

Fig. No.	Title	Page No.

List of Figures Cont…

List of Figures Cont...

Fig. No.	Title	Page No.

ABSTRACT

Background: Cerebral AVMs are very rare lesions, and this rarity contributes to the difficulty of treating them. There is no consensus concerning the method of treatment to be chosen among neurosurgery, radiosurgery or embolization.
Onyx embolization could serve as a curative option with accepted morbidity and mortality. The introduction of Onyx and of catheters with detachable tips has no doubt increased the rate of endovascular occlusion, and decreased the risks associated with treatment in our experience.

Objective: The aim of the study was to assess the outcome of the use of Onyx in the treatment of intracranial AVMs as curative embolization or before neuro- or radiosurgery

Patients and Methods: This analytical prospective study was conducted on 25 patients who were diagnosed with cerebral arteriovenous malformations and underwent endovascular embolization with EVOH copolymer with curative intent during the study period. Interventional procedures were done in the neuro –endovascular unit, neurosurgery department Ain Shams University Hospitals and associate neuroendovascular unit in El Matarya Teaching Hospital in the period between September 2014 and April 2017.

Results: Actually comparing these results especially concerning the cure rate along with other studies was somewhat confusing and problematic owing to the diversity in results between studies across the last 15 years.

Conclusion: For the cases that are not fulfilling these criteria, embolization should be offered as preparing step for other modality of treatment. In our experience, for curative embolization, the AVM should be small sized (< 3 cm), supplied by one vascular territory, with feeders that can tolerate reflux up to 2–3 cm, with clear proximal parts of the draining veins, and not located in deep structures.

Keywords: arteriovenous malformations **-** dimethyl-sulfoxide**.**

Introduction

Despite advances in neurosurgical and endovascular techniques, treatment of cerebral arteriovenous malformations (AVMs) remains challenging, often requiring a multidisciplinary approach. Nidus reduction before surgery or radiosurgery, curative embolization, and palliative embolization of AVMs are the different goals of endovascular treatment ***(Bruno and Meyers, 2012).***

Since the first report in the early**1960s** about transcatheter embolization of cerebral AVMs, a considerable evolution of microcatheter tools, embolization materials, and techniques has improved the success of embolization. Onyx (ev3, Irvine, California) was introduced a few years ago as a new embolic material for the endovascular treatment of cerebral AVMs. It consists of an ethyl-vinyl alcohol **(EVOH)** copolymer dissolved in dimethyl-sulfoxide **(DMSO)** with tantalum powder added for radio-opacity ***(Flores et al., 2014).***

Its slow solidification allows for more prolonged and controlled injection which permits theoretically slower filling, better penetration, and obliteration of the nidus. The introduction of Onyx into our embolization practice has brought a different endovascular treatment philosophy in which a “cure” is intended in all cerebralAVMs, rather than being a presurgical procedure.

The aim of the embolization has become, primarily, to cure all small- to medium-sized AVMs by embolization alone and secondly, to reduce the size of the larger AVMs ***(Saatci et al., 2011).***

AIM OF THE STUDY

Overall the aim of the study is to assess the outcome of the use of Onyx in the treatment of cerebral AVMs as curative embolization or before neuro- or radiosurgery as follows:

- Evaluation of the rates of initial obliteration of AVMs as well as the reperfusion rates after embolization.
- Assessment of the safety and efficacy of endovascular use of onyx focusing on the embolization techniques.
- Analysis of the angioarchitectural features of AVMs in which the injection of Onyx is successful and in which the technique fails.

AVM Definition and History

Definition

Cerebral arteriovenous malformations (AVMs) can be defined as pathological, congenital vascular lesions that may appear throughout the central nervous system. They consist of direct connections between arteries and veins through an intervening dysplastic vascular core “nidus” , without the normal interposed capillary bed **(Fig 1)**. This allows high-flow, rapid arteriovenous shunting, thereby inducing arterial hypotension in vessels feeding the arteriovenous malformation and neighboring areas of the brain ***(Tanaka, 2017).***

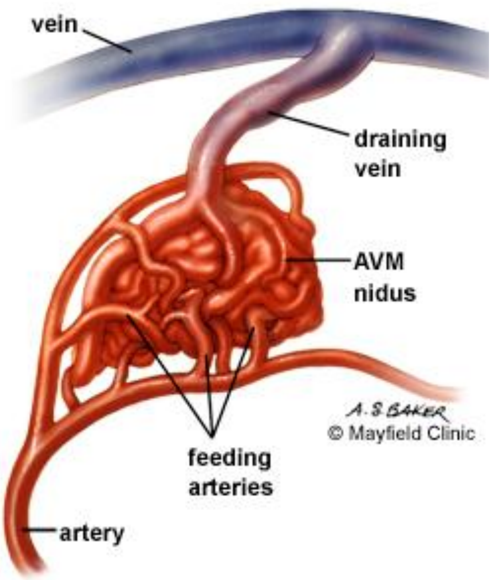

Fig. (1): Diagrammatic illustration of cerebal arteriovenous malformation.
(Tanaka, 2017)

Chronological History of AVMs:

The first pathological description of AVM was originated by ***Virchow*** in **1863**. The first complete excision of a cerebral AVM was made by ***Jules-Émile Péan*** in 1889.Vilhelm Magnus in 1914 was the first to treat cerebral AVMs using conventional fractionated radiation ***(Beneš & Bradáč, 2017).***

In 1927, ***Egas Moniz*** was the first to perform successful cerebral angiogram by direct carotid injection, which left a big impact on the diagnosis and understanding of AVMs. ***Herbert Olivecrona*** in 1932 successfully removed an AVM introducing the technique of ligating superficial feeding vessels, and to leave the ligation of the draining veins as a final step ***(Colby et al., 2012).***

Luessenhop and William Spence in **1960s** developed the endovascular techniques by blocking abnormal feeding vessels by direct puncture embolic material. Limited progress was made with AVM embolization during the **1960s**. Yasargil in **1969** had the first published microsurgical resection of AVM series ***(Colby et al., 2012)***.

Advancements in catheter design in the **1980s** permitted selective cannulation of the AVM arterial pedicles. An array of embolic agents was used in this decade, including silk threads, alcohol, and polyvinylalcohol (PVA). ***Robert Spetzler and Neil Martin*** in **1986** published AVM classification scheme ***(Beneš & Bradáč, 2017).***

During the **1990s**, NBCA and polyvinyl alcohol emerged as the most popular embolization materials for AVMs. Onyx was introduced in **1990** and received FDA approval for presurgical embolization of AVMs in **2005** ***(Al Awar and Patel, 2017).***