

Hydrocephalus caused by unilateral foramen of Monro obstruction: A review on terminology

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Abstract

Background: Hydrocephalus caused by unilateral foramen of Monro (FM) obstruction has been referred to in literature by many different terminologies. Precise terminology describing hydrocephalus confined to just one lateral ventricle has a very important prognostic value and determines whether or not the patient can be shunt free after an endoscopic procedure.

Methods: Aiming to define the best term for unilateral FM obstruction, 19 terms were employed on PubMed database (<http://www.ncbi.nlm.nih.gov/pubmed>) as quoted phrases.

Results: A total of 194 articles were found. Four patterns of hydrocephalus were discriminated as a result of our research term query and were divided by types for didactic purpose. Type A - partial dilation of the lateral ventricle; Type B - pure unilateral obstruction of the FM; Type C - previously shunted patients with secondary obstruction of the FM; and Type D - asymmetric lateral ventricles with patent FM.

Conclusion: In unilateral FM obstruction hydrocephalus, an in-depth review on terminology application is critical to avoid mistakes that may compromise comparisons among different series. This terminology review suggests that Type B hydrocephalus, i.e., the hydrocephalus confined to just one lateral ventricle with no other sites of cerebrospinal fluid circulation blockage, are best described by the terms unilateral hydrocephalus (UH) and monoventricular hydrocephalus, the first being by far the most popular. Type A hydrocephalus is best represented in the literature by the terms uniloculated hydrocephalus and loculated ventricle; Type C hydrocephalus by the terms isolated lateral ventricle and isolated UH; and Type D hydrocephalus by the term asymmetric hydrocephalus.

Key Words: Foramen of Monro, isolated lateral ventricle, monoventricular hydrocephalus, unilateral hydrocephalus

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INTRODUCTION

Unilateral ventricle dilation, unrelated to ex-vacuum hemisphere atrophy,^[68] is caused by unilateral foramen of Monro (FM) obstruction.^[22,80] It may be just an obstructed compartment within a more complex hydrocephalus or a unique compartment with hydrocephalus. Hydrocephalus caused by unilateral FM obstruction has been referred to in literature by many different terms. Precise terminology describing hydrocephalus confined to just one lateral ventricle has a very important prognostic value and determines whether or not the patient can be shunt free after endoscopic procedure.^[32,36] Here, we discuss terminology for unilateral FM obstruction hydrocephalus based on literature review.

METHODS

The terms asymmetric hydrocephalus (AH), asymmetric lateral ventricle, asymmetric lateral ventricles, asymmetric ventricle, asymmetric ventricles, compartmentalized hydrocephalus, isolated lateral ventricle (ILV), isolated unilateral hydrocephalus (IUH), isolated ventricle, isolated ventricles, loculated hydrocephalus, loculated lateral ventricle, loculated ventricle (LV), monoventricular hydrocephalus (MH), trapped lateral ventricle, trapped ventricle, UH, unilateral ventriculomegaly, and uniloculated hydrocephalus (ULH) were employed on PubMed database (<http://www.ncbi.nlm.nih.gov/pubmed>) as quoted phrases. Only articles with clear described cases were selected. Review articles were excluded. Only human articles were considered. Bilateral FM obstruction articles were not included.

RESULTS

A total of 194 articles were found [Table 1]. As depicted on Figure 1, four general patterns of hydrocephalus were discriminated as a result of our research terms query and were divided by types for didactic purpose. Type A - partial dilation of the lateral ventricle, i.e., ventricular septa, ventricular cyst, or trigone obstruction; Type B - unilateral obstruction of the FM; Type C - previously shunted patients with secondary obstruction of the FM; and Type D - hydrocephalus with asymmetric lateral ventricles and patent FM.

DISCUSSION

The best term for pure unilateral FM obstruction shall be specific to describe hydrocephalus of the lateral ventricles at the foramina level and at the same time shall not be used to describe heart ventricles. The terms asymmetric lateral ventricle, asymmetric ventricle, loculated lateral ventricle, and trapped lateral ventricle disclosed no result [Table 1]. The terms isolated ventricle and isolated

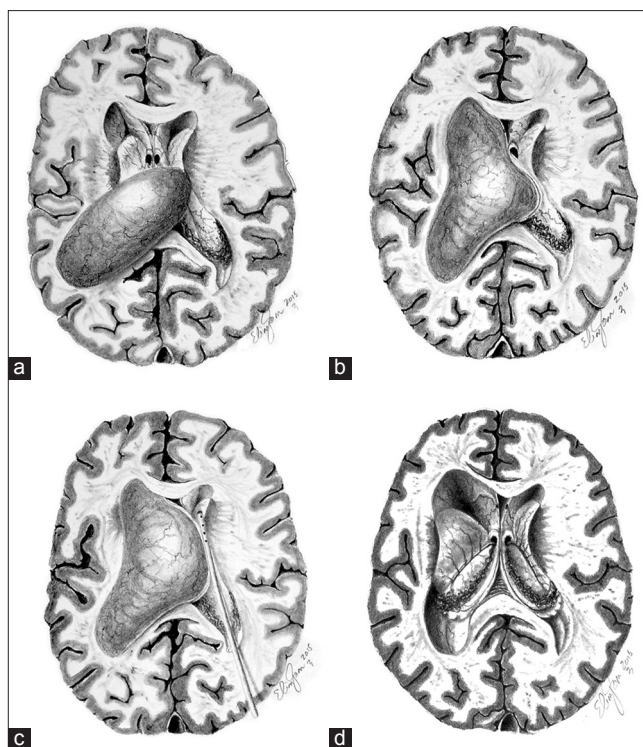


Figure 1: Schematic view of four different types of hydrocephalus described in the literature by the terms asymmetric hydrocephalus, isolated lateral ventricle, isolated unilateral hydrocephalus, loculated ventricle, monoventricular hydrocephalus, unilateral hydrocephalus, and uniloculated hydrocephalus. (a) Partial dilation of the lateral ventricle. (b) Exclusive unilateral obstruction of the foramen of Monro. (c) Secondary unilateral foramen of Monro obstruction in shunted patients. (d) Asymmetric lateral ventricles with patent foramen of Monro

ventricles are also used to describe heart ventricle disease [Table 1].^[55,86] The terms compartmentalized hydrocephalus,^[61] loculated hydrocephalus,^[6] and trapped ventricle^[29] although specific to brain ventricles are not specific for lateral ventricle involvement [Table 1]. The terms asymmetric lateral ventricles,^[89] asymmetric ventricles,^[9] and unilateral ventriculomegaly^[68] not always describe hydrocephalus [Table 1]. Then these terms did not seem appropriate for further discussion.

Obstruction of the FM causing dilation of ipsilateral ventricle admits several etiologies.^[32,48,84] It may be the single component of the hydrocephalus, or it may also be associated with other sites of cerebrospinal fluid (CSF) circulation blockage. Among all terms applied, the terms AH, ILV, IUH, LV, MH, UH, and ULH have shown to describe hydrocephalus of the lateral ventricles and not heart ventricles [Table 1]. For this reason, these terms were chosen for further discussion [Table 2].

Asymmetric hydrocephalus

The term AH literally means the coexistence of hydrocephalus with asymmetric ventricles. It can occur in patients with hydrocephalus and different size ventricles caused by congenital or acquired unilateral

Table 1: Literature review listing terminology as quoted phrases; number of articles found (n); ventricles involved in terminology description; if the term always described cases with hydrocephalus; and if the terms are used to describe heart ventricles

Terminology (quoted phrase)	n	Ventricles involved	Term always referred to hydrocephalus?	Term used for heart ventricles
AH	10	Lateral	Yes	No
Asymmetric lateral ventricle	0	-	-	-
Asymmetric lateral ventricles	4	Lateral	No	No
Asymmetric ventricle	0	-	-	-
Asymmetric ventricles	10	Lateral	No	No
Compartmentalized hydrocephalus	4	Lateral and IV	Yes	No
ILV	9	Lateral	Yes	No
IUH	4	Lateral	Yes	No
Isolated ventricle	14	Lateral and IV	No	Yes
Isolated ventricles	11	Lateral and IV	No	Yes
Loculated hydrocephalus	15	Lateral, III and IV	Yes	No
Loculated lateral ventricle	0	-	-	-
LV	2	Lateral	Yes	No
MH	6	Lateral	Yes	No
Trapped lateral ventricle	0	-	-	-
Trapped ventricle	3	Lateral and IV	Yes	No
UH	73	Lateral	Yes	No
Unilateral ventriculomegaly	25	Lateral	No	No
ULH	4	Lateral	Yes	No

AH: Asymmetric hydrocephalus, ILV: Isolated lateral ventricle, IUH: Isolated unilateral hydrocephalus, MH: Monoventricular hydrocephalus, UH: Unilateral hydrocephalus, ULH: Uniloculated hydrocephalus, LV: Loculated ventricle

brain atrophy.^[1] Durfee *et al.*, reserve the term AH for cases where asymmetrical dilation of the lateral ventricles has more than 2 mm, thus including patients sustaining bilateral and unilateral ventricular ectasia.^[27] According to the literature [Table 3], AH can mean any type of hydrocephalus depicted on Figure 1. Although it can be used to describe hydrocephalus caused by FM obstruction, it does not exclude cases with patent FM.^[10,46]

Isolated lateral ventricle

The term ILV literally means that the whole lateral ventricle is isolated from the rest of the ventricular system, including cases where patients also have other sites of CSF circulation obstruction. The literature review has shown that ILV has been employed to designate communicating hydrocephalus associated with postshunt FM obstruction,^[7,39,73,76] pure lateral ventricle hydrocephalus^[48] and also combining the two conditions.^[36] Krucoff *et al.* used the term ILV as a UH synonym.^[48]

Table 2: Literature review listing terminology, type of hydrocephalus as depicted in Figure 1, and authors' affiliation country

Author and year	Terminology	Type	Country
Abdel-Salam <i>et al.</i> 2011 ^[1]	AH	D	Egypt
Atalay <i>et al.</i> 2006 ^[10]	AH	C	Turkey
Bhattacharyya <i>et al.</i> , 2010 ^[14]	AH	A	India
Durfee <i>et al.</i> 2001 ^[27]	AH	B + D	USA
Kehler <i>et al.</i> 1997 ^[46]	AH	B + C	Germany
Ang <i>et al.</i> 2006 ^[7]	ILV	C	Canada
Hamada <i>et al.</i> 2003 ^[36]	ILV	B + C	Japan
Hubballah and Hoffman 1987 ^[39]	ILV	C	Canada
Krucoff <i>et al.</i> 2015 ^[48]	ILV	B	USA
Schulz <i>et al.</i> 2013 ^[73]	ILV	C	Germany
Steinbok <i>et al.</i> 1994 ^[76]	ILV	C	Canada
Hayashi <i>et al.</i> 1990 ^[37]	IUH	C	Japan
Oi <i>et al.</i> 1999 ^[64]	IUH	C	Japan
Oi and Enchev 2008 ^[63]	IUH	B	Japan
Salmon 1970 ^[69]	IUH	C	USA
Oi <i>et al.</i> 1999 ^[64]	LV	A	Japan
Schlitt <i>et al.</i> 1986 ^[70]	LV	A	USA
Abderrahmen <i>et al.</i> 2008 ^[2]	MH	B	Tunisia
Alonso <i>et al.</i> 1979 ^[4]	MH	B	Spain
Cai <i>et al.</i> 2013 ^[18]	MH	B	China
Freppel <i>et al.</i> 2009 ^[31]	MH	B	France
Gangemi <i>et al.</i> 1999 ^[32]	MH	B + C	Italy
Alexander and Botterell 1949 ^[3]	UH	B	USA
Anderson <i>et al.</i> 1993 ^[5]	UH	B	New Zealand
Aydin <i>et al.</i> 2007 ^[11]	UH	B	Turkey
Baumann <i>et al.</i> 1982 ^[12]	UH	B	Israel
Bhagwati 1964 ^[13]	UH	B	USA
Boyar <i>et al.</i> 1993 ^[15]	UH	B	Turkey
Brück <i>et al.</i> 1991 ^[16]	UH	A	Germany
Burtscher <i>et al.</i> 2003 ^[17]	UH	B	Germany
Cantini <i>et al.</i> 1980 ^[19]	UH	C	Italy
Chang <i>et al.</i> 1991 ^[20]	UH	B	USA
Chun <i>et al.</i> 2011 ^[21]	UH	B	South Africa
Dastgir <i>et al.</i> 2006 ^[23]	UH	B	Saudi Arabia
de Vries <i>et al.</i> 2000 ^[24]	UH	B	The Netherlands
Decq <i>et al.</i> 1994 ^[25]	UH	B	France
Dorwling-Carter <i>et al.</i> 1987 ^[26]	UH	B	France
Fondop <i>et al.</i> 2010 ^[30]	UH	B	France
Gaston and Jones 1989 ^[33]	UH	B	USA
Greenlee <i>et al.</i> 2008 ^[34]	UH	B	USA
Hageman <i>et al.</i> 1985 ^[35]	UH	B	The Netherlands
Hongo <i>et al.</i> 2001 ^[38]	UH	B	Japan
Husag <i>et al.</i> 1976 ^[40]	UH	B	German
Ismail <i>et al.</i> 2001 ^[41]	UH	B	Kwait
Ito <i>et al.</i> 1978 ^[42]	UH	B	Japan
Jeon <i>et al.</i> 2005 ^[43]	UH	B	Korea
Jivan <i>et al.</i> 2010 ^[44]	UH	B	South Africa
Kasantikul <i>et al.</i> 1987 ^[45]	UH	B	Thailand

Contd...

Table 2: Contd...

Author and year	Terminology	Type	Country
Koga <i>et al.</i> 1997 ^[47]	UH	B	Japan
Kumar 1999 ^[50]	UH	B	India
Kumar and Bhagat 2012 ^[49]	UH	B	India
Lazareff and Sadowinski 1992 ^[51]	UH	C	Mexico
Leonardo and Grand 2009 ^[52]	UH	B	USA
Mampalam <i>et al.</i> 1991 ^[54]	UH	B	USA
Zoran <i>et al.</i> 2011 ^[90]	UH	B	Serbia
Milhorat <i>et al.</i> 1975 ^[56]	UH	B	USA
Miyahara <i>et al.</i> 2008 ^[57]	UH	B	Japan
Mohanty <i>et al.</i> 1996 ^[58]	UH	B	India
Nakamura <i>et al.</i> 1989 ^[59]	UH	B	Japan
Nishizaki <i>et al.</i> 1990 ^[60]	UH	D	Japan
Ohkawa <i>et al.</i> 1993 ^[62]	UH	B	Japan
Oi <i>et al.</i> 1985 ^[65]	UH	B	Japan
Patten <i>et al.</i> 1991 ^[66]	UH	B	USA
Pfeiffer and Friede 1984 ^[67]	UH	B	Germany
Schroeder 2013 ^[71]	UH	B	Germany
Schulman <i>et al.</i> 2000 ^[72]	UH	B	Israel
Sharifi <i>et al.</i> 2010 ^[74]	UH	B	Iran
Singh <i>et al.</i> 2011 ^[75]	UH	B	India
Suzuki <i>et al.</i> 1985 ^[77]	UH	D	Japan
Takeshita <i>et al.</i> 1980 ^[78]	UH	A	Japan
Terrier <i>et al.</i> 1992 ^[79]	UH	B	France
Tien <i>et al.</i> 1990 ^[81]	UH	B	USA
Tillmann <i>et al.</i> 2004 ^[82]	UH	B	Switzerland
Vajramani <i>et al.</i> 1999 ^[83]	UH	B	India
Vaz-Guimarães Filho <i>et al.</i> 2011 ^[84]	UH	B	Brazil
Venkataramana <i>et al.</i> 1989 ^[85]	UH	B	India
Whyte 2011 ^[87]	UH	B	USA
Wilberger <i>et al.</i> 1983 ^[88]	UH	B	USA
Andresen and Juhler 2012 ^[6]	UH	B + C	Denmark
El-Ghandour 2013 ^[28]	UH	A + B + C	Egypt
Lewis <i>et al.</i> 1995 ^[53]	UH	A + B + C	USA
Nowoslawska <i>et al.</i> 2003 ^[61]	UH	B	Poland

Data is sorted by terminology, type of hydrocephalus, then author. AH: Asymmetric hydrocephalus, ILV: Isolated lateral ventricle, IUH: Isolated unilateral hydrocephalus, MH: Monoventricular hydrocephalus, UH: Unilateral hydrocephalus, LV: Loculated ventricle

Isolated unilateral hydrocephalus

The term IUH has been used to indicate that the hydrocephalus is confined to one brain side including complete or partial lateral ventricle dilation. In the literature, this term specifically refer to FM obstruction, but it is employed in situations when hydrocephalus is restricted^[63] and also when not restricted^[37,64,69] to the lateral ventricle [Table 2].

Loculated ventricle

The term LV literally describes a compartment separated from the rest of the ventricular system. It has been applied on situations where there is a partial dilation of the lateral ventricle, like Type A depicted on Figure 1.^[64,70]

Monoventricular hydrocephalus

The term MH specifically defines a single lateral ventricle obstruction that by anatomical reasons can only indicate the involvement of the lateral ventricle, inasmuch as an obstruction of the third ventricle or fourth ventricles will necessarily cause biventricular and triventricular hydrocephalus respectively. Indeed, the term MH has been used to describe hydrocephalus restricted to one lateral ventricle, as shown in four articles [Table 3]. However, Gangemi *et al.* included cases with FM obstruction associated with communicating hydrocephalus.^[32] Furthermore, there is a logical preference for terms describing the number of ventricles involved, such as monoventricular, biventricular, triventricular, and tetraventricular hydrocephalus, as described in Mori and Raimondi's classification of hydrocephalus.^[8] Cultural influence seems to play an important role in terminology choice. Eighty percent of articles using the term MH come from Latin language speaking countries [Table 4].

Unilateral hydrocephalus

The term UH literally means that the hydrocephalus is confined to one brain side. It may indicate a complete or partial dilation of the lateral ventricle. Probably due to the universal use of English language [Table 4] the term UH is by far the most commonly employed in Type B hydrocephalus [Figure 1] as shown in fifty articles [Table 3]. However, it has also been employed through literature in different types of hydrocephalus [Table 3]. Brück *et al.*,^[16] and Takeshita *et al.*,^[78] used the term UH not describing FM obstruction, but in cases with partial dilation of the lateral ventricle. Cantini *et al.*,^[19] and Lazareff and Sadowinski,^[51] used the term UH for cases of hydrocephalus not restricted to the lateral ventricle. Nishizaki *et al.*, described a case of biventricular hydrocephalus, which he designated left dominant UH.^[60] Hageman *et al.*, described an arthrogryposis newborn with left lateral ventricle dilation, midline shift, asymmetric head, and right hemiparesis.^[35] Although it may be considered a case of UH, the abnormality was diagnosed as unilateral cerebral hypoplasia, so no treatment was indicated. Suzuki *et al.* described a case of unilateral hydranencephaly and named it UH.^[77] The term bilateral hydrocephalus, albeit employing the same terminological criteria as UH, is not frequently employed.

Uniloculated hydrocephalus

The term ULH literally means that a ventricle is compartmentalized or is by itself a unique hydrocephalic compartment. El-Ghandour,^[28] and Lewis *et al.*,^[53] use the term ULH as a general term describing cases with partial dilation of the lateral ventricle, complete dilation of one lateral ventricle, and shunt complicated unilateral FM obstruction. Nowoslawska *et al.*, use to describe a pure FM obstruction case [Table 2].^[61] Andresen and

Table 3: Number of articles matching terminology (rows) with type of the hydrocephalus as depicted in Figure 1 (columns)

	Type A	Type B	Type C	Type D	Type B + C	Type B + D	Type A + B + C
AH	1	0	1	1	1	1	0
ILV	0	1	4	0	1	0	0
IUH	0	1	3	0	0	0	0
LV	2	0	0	0	0	0	0
MH	0	4	0	0	1	0	0
UH	2	50	2	2	0	0	0
ULH	0	1	0	0	1	0	2

Data extract from table 2. AH: Asymmetric hydrocephalus, ILV: Isolated lateral ventricle, IUH: Isolated unilateral hydrocephalus, MH: Monoventricular hydrocephalus, UH: Unilateral hydrocephalus, ULH: Uniloculated hydrocephalus, LV: Loculated ventricle

Table 4: Distribution of terms appearing in articles dealing with foramen of Monro obstruction by country (from articles listed in Table 2)

Country	Total	AH	ILV	IUH	LV	MH	UH	ULH
Brazil	1	0	0	0	0	0	1	0
Canada	3	0	3	0	0	0	0	0
China	1	0	0	0	0	1	0	0
Denmark	1	0	0	0	0	0	0	1
Egypt	2	1	0	0	0	0	0	1
France	5	0	0	0	0	1	4	0
Germany	7	1	1	0	0	0	5	0
India	7	1	0	0	0	0	6	0
Iran	1	0	0	0	0	0	1	0
Israel	2	0	0	0	0	0	2	0
Italy	2	0	0	0	0	1	1	0
Japan	15	0	1	3	1	0	10	0
Korea	1	0	0	0	0	0	1	0
Kuwait	1	0	0	0	0	0	1	0
Mexico	1	0	0	0	0	0	1	0
The Netherlands	2	0	0	0	0	0	2	0
New Zealand	1	0	0	0	0	0	1	0
Poland	1	0	0	0	0	0	0	1
Saudi Arabia	1	0	0	0	0	0	1	0
Serbia	1	0	0	0	0	0	1	0
South Africa	2	0	0	0	0	0	2	0
Spain	1	0	0	0	0	1	0	0
Switzerland	1	0	0	0	0	0	1	0
Thailand	1	0	0	0	0	0	1	0
Tunisia	1	0	0	0	0	1	0	0
Turkey	3	1	0	0	0	0	2	0
USA	17	1	1	1	1	0	12	1

AH: Asymmetric hydrocephalus, ILV: Isolated lateral ventricle, IUH: Isolated unilateral hydrocephalus, MH: Monoventricular hydrocephalus, UH: Unilateral hydrocephalus, ULH: Uniloculated hydrocephalus, LV: Loculated ventricle

Juhler, proposed a very practical classification dividing hydrocephalus in loculations and its variants.^[6] Loculated

hydrocephalus is a condition in which discrete fluid-filled compartments form in or in relation to the ventricular system of the brain.^[6] Applying Andresen and Juhler, classification in FM obstruction situations, pure FM obstruction [Figure 1, Type B] is termed “simple uniloculated hydrocephalus” and FM obstruction associated with communicating hydrocephalus [Figure 1, Type C] is classified as “complex uniloculated hydrocephalus.”^[6]

Term meaning X application in the literature

Table 5 depicts the comparison of the literal meaning of a terminology and how this term is used in the literature. All the terms show a strong correlation between terminology meaning and application in the literature, but there is some misuse that may cause confusion.

Endoscopic treatment of unilateral foramen of Monro obstruction hydrocephalus

Since 1994, endoscopy is the treatment of choice for Type A, Type B, and Type C hydrocephalus.^[2,7,11,17,18,21,25,30-32,34,36,38,43,44,48,50,52,58,63,64,71,73,75,82,84,87] Many endoscopic techniques have been employed with high success rates such as septostomy,^[2,7,17,18,25,30-32,34,36,38,48,50,52,58,64,71,73,75,82,84,87] open membranes,^[11,34,58] lesion removal,^[36,43,44,84] Monro foraminoplasty,^[21,48,50,63,64,84] and cyst fenestration.^[31,32] Some authors still prefer standards methods like shunt,^[23,47,72,90] open craniotomy lesion removal and shunt,^[83] and Rickham reservoir and shunt.^[24] Endoscopic technique to communicate ventricular compartments is not indicate for Type D hydrocephalus where both FM are patent. On Type B hydrocephalus, patients are shunt free after endoscopic treatment of hydrocephalus.^[2,11,17,18,21,30-32,34,38,43,44,48,52,58,75,82,84,87] On Type C hydrocephalus, the endoscopic technique is employed to avoid a second shunt implantation, and the patient remains shunt-dependent.^[7,32,64,73]

CONCLUSION

This study indicates that, in unilateral FM obstruction hydrocephalus, a thorough review of the terminology application is critical to avoid mistakes that may compromise comparisons among different series. There are different terminologies meaning the same and also cases where the same terminology is applied for different clinical situations. This terminology review suggests that Type B hydrocephalus, i.e., the hydrocephalus confined to just one lateral ventricle with no other sites of CSF circulation blockage, are best described by the terms UH and MH hydrocephalus, the first being by far the most popular. Type A hydrocephalus is best represented in the literature by the terms ULH and LV, Type C hydrocephalus by the terms ILV and IUH; and Type D hydrocephalus by the term AH.

Table 5: Comparison of the term meaning and its application in the literature

	Literally meaning by type	Literature usage by type (%)
AH	A, B, C, D	A (14), B (29), C (29), D (29)
ILV	B, C	B (29), C (71)
IUH	A, B	B (25), C (75)
LV	A, B, C	A (100)
MH	B	B (83), C (17)
UH	A, B	A (4), B (89), C (4), D (4)
ULH	A, B	A (17), B (50), C (33)

The type of hydrocephalus is depicted on Figure 1. AH: Asymmetric hydrocephalus, ILV: Isolated lateral ventricle, IUH: Isolated unilateral hydrocephalus, MH: Monoventricular hydrocephalus, UH: Unilateral hydrocephalus, ULH: Uniloculated hydrocephalus

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Conflicts of interest

There are no conflicts of interest.

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