

# MRI Volumetry Longitudinal Regional Volume Curve

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## Regional MRI Volumetry and Longitudinal Regional Volume Curve for Detecting Hippocampal Sclerosis in Temporal Lobe Epilepsy

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**Background** : In order to improve MRI volumetry of hippocampus, we obtained the Longitudinal Regional Volume Curve (LRVC) of hippocampi and compared the sensitivity of LRVC with those of conventional hippocampal volumetries (total and regional) in temporal lobe epilepsy (TLE). **Methods** : Thirty-eight normal subjects and 24 TLE patients were included in this study. The pathology of all patients showed hippocampal sclerosis. The volume of the hippocampus was measured by a manual tracing in 3 mm-thickness coronal MRI slices perpendicular to the long axis of the hippocampus and a three-dimensional reconstruction. Total volume and regional volumes (anterior, middle, and posterior 1/3) of the right and left hippocampi were measured. Then, the focal hippocampal volume of each of the coronal slices (3 mm) was plotted in a X-Y graph to obtain LRVC. The presence and pattern of HA were determined in LRVC. **Results** : The mean volume of right hippocampus (2512±629 mm<sup>3</sup>) was bigger than that of the left one (2262.6±563.2 mm<sup>3</sup>) in normal subjects. The normal range of right-left total volume difference was 3.6~495.2 mm<sup>3</sup>. The sensitivities of conventional volumetry, regional volumetry, and LRVC were 66.7%, 75%, and 83.3%, respectively. Eleven patients showed diffuse HA (11/20, 55.0%) and nine had focal HA (9/20, 45.0%). In focal HA, the middle and posterior HA were more frequent (6/9, 66.7%) than anterior HA. **Conclusions** : LRVC improved the sensitivity of MRI volumetry in detecting hippocampal sclerosis and could reveal the pattern (diffuse or focal) of HA.

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**Key Words** : Hippocampal sclerosis, MRI volumetry, Regional volumetry, Longitudinal regional volume curve, Temporal lobe epilepsy

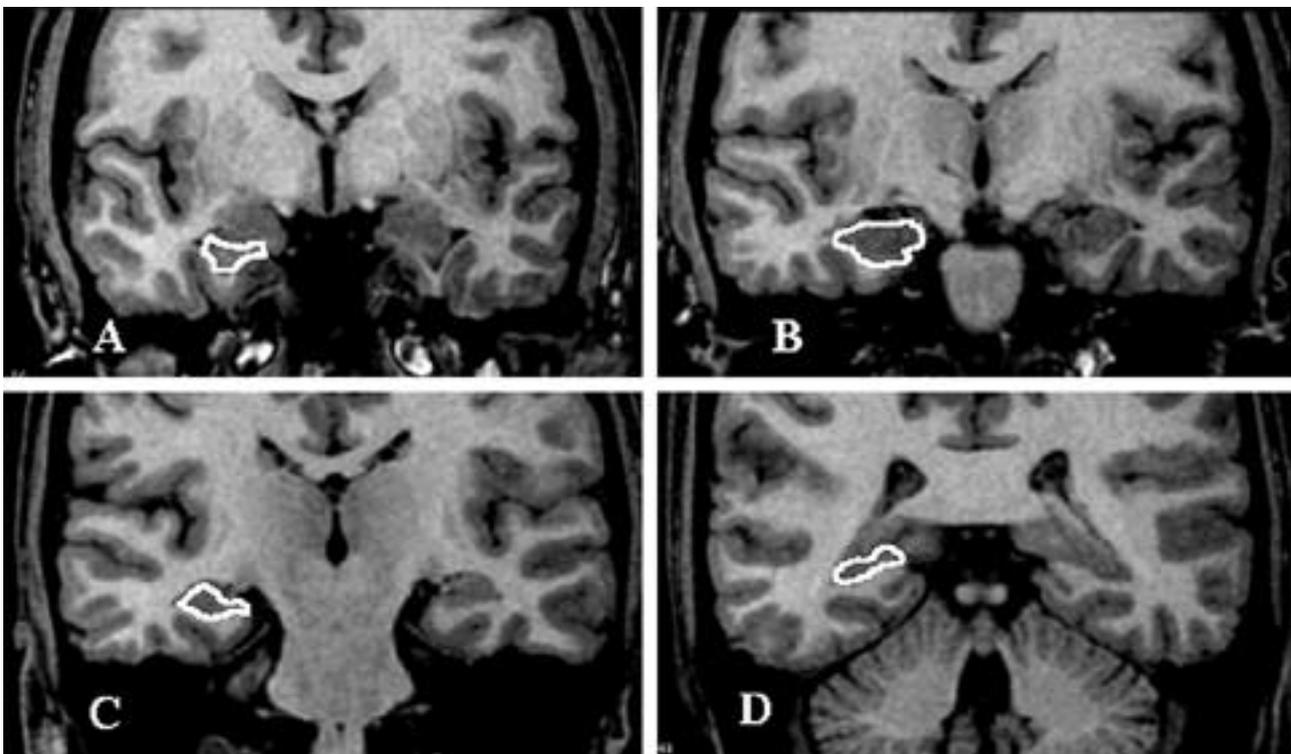
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가 ,  
<sup>12,13</sup>  
 , Longitudinal Regional  
 Volume Curve(LRVC) MRI  
 , 1)  
 , 2) 3) MRI  
 (LRVC) 가  
 .  
 2~3  
 24 ,  
 12 , 12  
 . 28 (14~43 ) , 가 14  
 가 10 .  
 38 19~43 ,  
 가 20 , 18 .  
 (Mean - 2  
 SD)~(Mean + 2SD)  
 ( 1/3, 1/3, 1/3)  
 , (Mean - 2SD)~(Mean +  
 2SD) . MRI 2 (two coronal  
 slices, 3 mm )

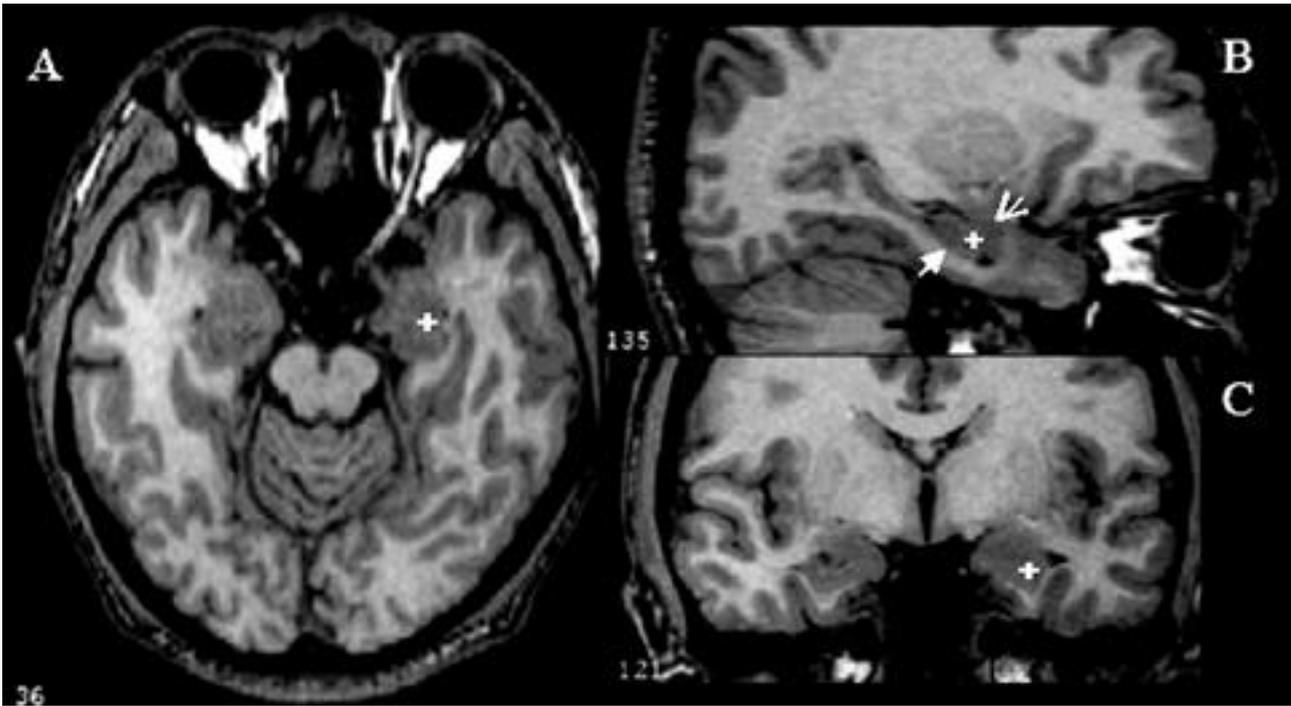
(LRVC) .  
 1.  
 1.5 Tesla GE MRI scanner  
 , SPGR(Spoiled gradient echo technique)  
 , 1.5 mm  
 .  
 volumetry software(Analyze 7.5 version)

(Fig. 1).  
 (alveus) ,  
 sagittal, axial, coronal images  
 orthogonal view  
 (Fig. 2).

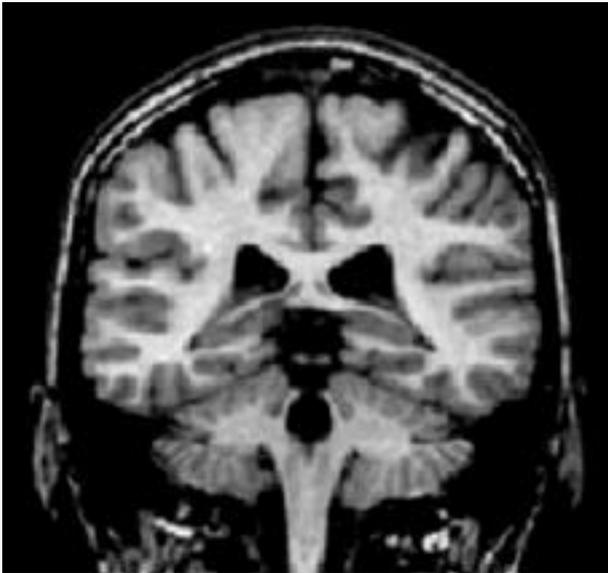
3  
 가  
 (crus of fornix)가  
 (Fig.  
 3).  
 1/3, 1/3, 1/3  
 , , , 1/3  
 (Mean  
 - 2SD)~(Mean + 2SD)  
 (R-L )  
 1/3



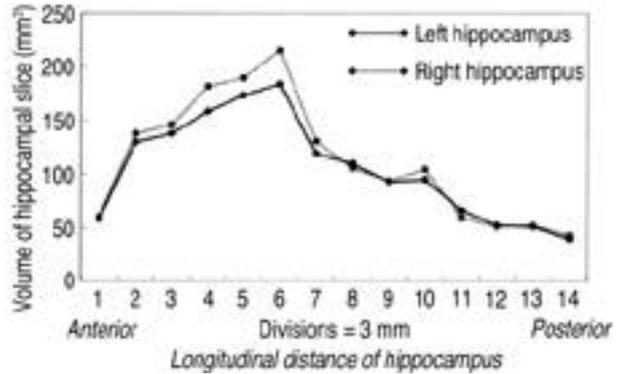
**Figure 1.** A manual tracing of hippocampal formation (white outline). An image analyst who had much experience in hippocampal volumetry measured hippocampal volumes of all normal subjects and patients. (A, B: head of hippocampus, C: body of hippocampus, D: tail of hippocampus)



**Figure 2.** The border between hippocampus and amygdala. The border was determined by an orthogonal view method of displaying simultaneous axial (A), sagittal (B) and coronal (C) images at each pixel point of MRI image. Sagittal image shows a white alveus between hippocampus (↖) and amygdala (↗) indicated by a white cross mark (+) which provides its coordinate in axial and coronal images.



**Figure 3.** The posterior end of hippocampus. The posterior end of hippocampal volumetry was decided when the crus of fornix appeared on coronal MR image.



**Figure 4.** Slice by slice hippocampal formation volume versus longitudinal regional volume curve of normal subject. The y-axis represents the hippocampal volume of each slice (mm<sup>3</sup>). The x-axis is marked in 3 mm divisions (slice thickness) of hippocampus. Right hippocampal formation appears to be slightly bigger than the left one.

(3.0 mm )  
 X-Y  
 Longitudinal Regional Volume  
 Curve(LRVC) (Fig. 4).  
 LRVC LRVC

(Fig. 4, 5).  
 1.  
 2512 ± 629 mm<sup>3</sup>,  
 가  
 2262.6 ± 563.2 mm<sup>3</sup> R-L  
 (paired t-test, p < 0.05). R-L  
 249.4 ± 122.9 mm<sup>3</sup> R-L

3.6 ~ 495.2 mm<sup>3</sup> (Table 1).  
 1/3, 1/3,  
 1/3 R-L  
 (Table 2). , 1/3  
 R-L 1/3 - 114.2~273.4  
 mm<sup>3</sup>, 1/3 - 53.8~281.0 mm<sup>3</sup>, 1/3 -  
 70.0~131.6 mm<sup>3</sup> (Table 3).  
 2.  
 가 1811.4

±374.4 mm<sup>3</sup>, 2124.7±477.6  
 mm<sup>3</sup> 가 가  
 (Wilcoxon signed ranks test, p<0.05). ,  
 가 2228.0±  
 528.4 mm<sup>3</sup>, 1736.0±551.8  
 mm<sup>3</sup> 가 (p<0.01).  
 - (R-L Difference)  
 - 313.3±570.2 mm<sup>3</sup>, 493.0±  
 584.8 mm<sup>3</sup>  
 가 (Mann-Whitney U test, p<0.01).

**Table 1.** Right and left total hippocampus volumes and R-L volume difference in normal controls.

	Volume(Mean±SD, mm <sup>3</sup> )
Right hippocampus	2512.0±629.4*
Left hippocampus	2262.6±563.2
R-L volume difference <sup>†</sup>	249.4±122.9
Normal range of	
R-L volume difference <sup>‡</sup>	3.6~495.2

\* Right hippocampus volume is bigger than left hippocampus volume(p<0.01, paired t-test).

<sup>†</sup> R-L volume difference: right hippocampus volume - left hippocampus volume(mm<sup>3</sup>)

<sup>‡</sup> Normal range of R-L volume difference: [(mean-2SD)~(mean+2SD)] of R-L volume difference

**Table 2.** Regional hippocampus volumes and R-L volume difference\* in normal controls.

Region of hippocampus	Right	Left
Anterior 1/3	994.2±171.1	914.6±151.6
R-L volume difference	79.6±96.9	
Middle 1/3	947.1±356.9	833.5±317.6
R-L volume difference	113.6±83.7	
Posterior 1/3	483.4±167.0	452.6±158.7
R-L volume difference	30.8±50.4	

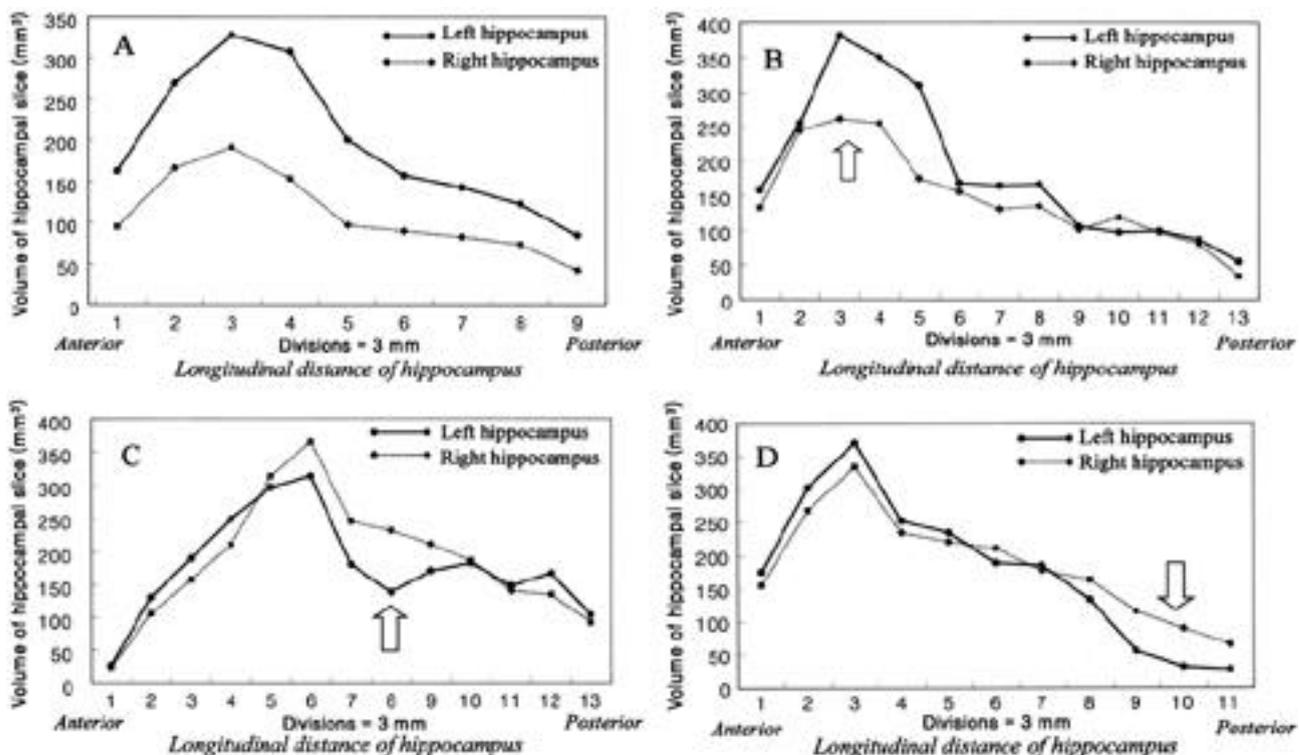
Numeric values are mean±SD.

Anterior 1/3; volume of anterior 1/3 of total hippocampus

Middle 1/3; volume of middle 1/3 of total hippocampus

Posterior 1/3; volume of posterior 1/3 of total hippocampus

\* R-L volume difference: right 1/3 volume-left 1/3 volume (mm<sup>3</sup>)



**Figure 5.** Slice by slice hippocampal formation volume versus longitudinal regional volume curve. The x-axis is marked in 3 mm divisions (slice thickness) of hippocampus. **A.** It shows diffuse right hippocampal volume loss in a patient with right TLE. **B.** It reveals a focal right anterior hippocampal volume loss in a patient with right TLE. **C.** It demonstrates a focal left middle hippocampal volume loss in a patient with left TLE. **D.** It shows focal left posterior hippocampal volume loss in a patient with left TLE.

**Table 3.** The ranges of R-L volume differences\* in anterior, middle and posterior 1/3 of hippocampus in normal controls.

Region of hippocampus	Normal range of R-L volume difference (mean - 2SD)~(mean + 2SD)
Anterior 1/3	-114.2~273.4 mm <sup>3</sup>
Middle 1/3	-53.8~281.0 mm <sup>3</sup>
Posterior 1/3	-70.0~131.6 mm <sup>3</sup>

Anterior 1/3; volume of anterior 1/3 of total hippocampus  
 Middle 1/3; volume of middle 1/3 of total hippocampus  
 Posterior 1/3; volume of posterior 1/3 of total hippocampus  
 \* Right 1/3 volume - left 1/3 volume

**Table 4.** Patterns\* of hippocampal atrophy

Diffuse atrophy	11/20(55%)
Focal atrophy	9/20(45%)
Anterior	2/20(10%)
Middle	3/20(15%)
Posterior	1/20(5%)
Anterior+Posterior	1/20(5%)
Middle+Posterior	2/20(10%)

\*The patterns of hippocampal atrophy were determined by Longitudinal Regional Volume Curve of each patient.

**Table 5.** The sensitivity of MRI Volumetry in detecting hippocampal sclerosis.

Method of Volumetry	Sensitivity
Total Hippocampal Volumetry	
1) General normal range(-200~400 mm <sup>3</sup> )*	14/24(62.5%)
2) SMC normal range(3.6~495.2 mm <sup>3</sup> )*	16/24(66.7%)
Regional Volumetry	18/24(75%)
LRVC	20/24(83.3%)

\* normal range of R-L total hippocampal volume difference  
 SMC; Samsung Medical Center  
 LRVC; Longitudinal Regional Volume Curve

3. (Fig. 5-A, B, C, D) 11 (55%), 9 (45%), 1/3 (Fig. 5B) 2 (10%), 1/3 (Fig. 5C) 3 (15%), 1/3 (Fig. 5D) 1 (5%), 1/3 1 (5%), 1/3 2 (10%) (Table 4).

4. LRVC 가 66.7% 가 75% 가 83.3% (Table 5).

가 Baulac 1, Kuzniecky 5, MRI volumetry 가 12, 3,7,10,14-17,21

Cook Y X 1.5 mm 가 20 12 가 60% 가 13 Quigg 가 43 4 (9%), 13 (30%), 11 (26%), 15 (35%), 11 (55%), 9 (45%)

1/3 1/3

, Cook

Cook Quigg

가

<sup>12,13</sup>

LRVC

volumetry 가

(amygdala) 가

가 3

가

가

<sup>10,18,22</sup>

가

( > 400 : , < - 200 : )

62% , 가 가 1

66.7%

가 , vol-

umetry

Longitudinal Regional Volume Curve  
volumetry

volumetry

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