

**YES(Yonsei embolic
substance), Polyvinyl alcohol Gelfoam
가**

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- Fig. 1. CT/MRI image of saline, PVA, YES:..... 5
 (a) CT image shows characteristic high attenuation of YES.
 (b) MRI T2 weighted image shows low signal intensity compared to saline.
- Fig. 2. Microscopic photo of Embolic Material. A bead indicated by black arrow is made of only PVA, but others are of PVA+Pt/TiO₂(x 100).7
- Fig. 3. Post-contrast CT images at 2 weeks after embolization: 16
 (a)Partially occluded Rt. renal artery of YES group shows cortical rim sign.
 (b)Nearly complete obstructed Rt. renal artery of PVA group shows cortical rim sign.
- Fig. 4. Pre-contrast CT image of embolized Rt. kidney 2 weeks after embolization in YES group: high attenuation areas suggestive of YES particle are seen at corticomedullary junction(a,b).17
- Fig. 5. CT and MRI image of YES group at 2 weeks after embolization 17
 (a) YES particles are readily visible on pre-contrast CT.
 (b) YES particle is not definite on MRI T2 weighted image alone. Differentiation from other structure Differentiation from other structures, such as signal void of vascular structure, are impossible.

- Fig. 6 (a) Gross findings of embolized kidneys on 8 weeks after embolization: Distinct differences in viability are present between the totally necrotic, small yellowish YES-embolized kidney(left) and congested but relatively normal kidney(right). (b) Gross specimens of embolized kidney on 8 weeks after embolization with PVA(left) shows markedly thickened perirenal fat with inflammatory change and yellowish appearance as compared with normal kidney(right).18
- Fig. 7. Sections obtained 8 weeks after embolization with 150-250 μ m YES: Several YES particles are seen in vascular lumen with without aggregation or adhesion (hematoxylin-eosin, x100).20
- Fig. 8 Microphotograph of embolized vessel, after 8weeks of YES embolization. The occluded vessels and surrounding parenchyma were mildly infiltrated by multinucleated giant cells, eosinophils, lymphocytes and few neutrophils (hematoxylin-eosin, x 200). 20
- Fig. 9. Microphotograph of embolized nidus, after 8weeks of embolization. (a) Occlusion of a large vessel at the renal hilum by an organizing mass of PVA particles is seen. Near total coagulation necrosis, calcification and infiltration of inflammatory cells are present (hematoxylin-eosin, original magnification x100). (b) Another area shows capillary recanalization and thickened vascular wall(hematoxylin-eosin, x200). 21
- Fig. 10. Sections obtained 8 weeks after embolization with Gelfoam: Near total vascular occlusion and coagulation necrosis of renal parenchyma are seen. Gelfoam particles are not seen in vessel lumen (hematoxylin-eosin, x40). 22

Table 1. Angiographic findings of YES, PVA and Gelfoam group after embolization.14

Table 2. Perfusion units (PU) of each embolic materials, YES, PVA, and Gelfoam. The perfusion units were measured performed by Laser doppler flowmetry and digitized.15

Table 3. CT/MRI findings of YES, PVA and Gelfoam group.16

**YES(Yonseï embolic substance), Polyvinyl alcohol Gelfoam
가**

. YES(Yonseï Embolic Substance) (1
 μm) (TiO_2) PVA ,
 , 30 – 1000 μm
 . YES Gelfoam PVA
 CT MRI
 . 가
 , YES (150-250 microns) 4 , PVA (150-250 microns) 4 , Gelfoam 4
 3
 . 2 , 8 CT MRI
 , 8
 YES PVA 8
 Gelfoam 8 1
 . CT YES 2
 YES
 PVA Gelfoam
 YES
 , PVA Gelfoam
 ,
 YES
 . Gelfoam PVA
 . PVA
 ,
 PVA
 , . Gelfoam
 ,
 가 Gelfoam
 YES 가 ,

가 , .

: , , ,

,
 , CT/MRI 가
 가 Yonsei Embolic Substance (YES, Bokwang, Gumi,
 Korea) (1 μ m) (
 TiO₂) PVA YES PVA
 3 가 CT MRI
 CT YES HU
 PVA MRI T2
 PVA
 CT/MRI YES
 , 가
 , 30 – 1000 μ m
 .(1)

Fig 1-a

Fig 1-b

Fig. 1. CT/MRI image of saline(S), PVA(P), YES(Y): (1-a) CT image shows characteristic high attenuation of YES. (1-b) MRI T2 weighted image shows low signal intensity compared to saline.

YES Gelfoam PVA
 CT MRI

YES

3 7 % PVA 0.5 1.75 % Pt TiO₂
 30 °C 80 °C 가 PVA

,
 () 1kg 0.3 %
 70 °C 가 1200 rpm , PVA
 (Pt TiO₂)
 , 95 °C 110 °C 가
 4 PVA ,
 , n-
 .(2)

Fig. 2. Microscopic photo of Embolic Material. A bead indicated by black arrow is made of only PVA, but others are of PVA+Pt/TiO₂(original magnification x 100).

3kg 15 , YES (150-250
 microns) 4 YES , PVA(Boston Scientific, Massachusetts,
 USA, 150-250 microns) 4 PVA , Gelfoam(Ferrosan A-S
 International, Soeborg, Denmark) 가 , 1mm 4
 Gelfoam 3 .
 ()

atropin 0.08mg/kg
 rompun 4mg/kg ketamin HCL 50mg/kg
 mask enflurane MAC 2%
 , 20G
 , 0.035 (Terumo, Tokyo, Japan) 4 F
 (Terumo, Tokyo, Japan) X-
 0.1% 0.1ml 1:1
 4F 2.2F
 coaxial catheter(Boston Scientific, Messsachusetts, USA)

가

가

가

가

, YES PVA

5

2.2F coaxial catheter 0.014 inch diameter guide wire
 (Boston Scientific, Messsachusetts, USA) guide wire
 fine optic-fiber(probe B500, Perimed, Sweden, 300 μm diameter) laser
 flowmetry (Perimed, Jarfalla, Sweden)

8

, 8

Laser flowmetry

PeriFlux system

4000(Perimed, Jarfalla, Sweden)

perfusion unit

PeriFlux system 4000 Laser

Doppler Perfusion monitor

perfusion 가

probe(probe B500, Perimed, Sweden)가

CMBC (concentration of Moving blood cells),

velocity, TB(total backscatter), PU(perfusion unit)

, PU CMBC x Mean

velocity

probe

Periflux 4000 master monitor 가 Laser diode
 (780 nm wavelength with maximum emission energy of 0.8 mW)
 blood 가 , optical fiber
 photodetector .

Calibration probe standard solution (PF 1001, PeriMed, Jarfalla, Sweden)
 , flowmetry deflection 25%
 . 250 PU . PU .
 ANOVA test 95%(P<0.05)

CT/MRI

CT/ MRI 1 2 8 가
 , MRI 0.3T
 Hitachi MRP-7000 . FOV 20 cm
 , 256 x 256 pixel display matrix, 4mm , 1mm , NSA 4
 . T1 TR/TE 가 620/20 msec T2 TR/TE 가
 4000/117 msec FSE . CT Hitachi
 W2000 5mm (Nycomed,
 Cork, Ireland) 6cc (kg 2cc) . CT MRI
 2 ,

CT

8
 10%
 hematoxylin-eosin .

8

2

10%

21 가 YES 4 , PVA . YES
4 , Gelfoam 3 8 . YES
4 가 . 8 가
8 , 6 24 .
, 1 14 7 .
PVA 4 가 8 ,
Gelfoam 5 2 가 7 가 8
3 .
. YES 4
, PVA 4 2 2
, Gelfoam 3
YES 5 , 8
. PVA 5
4 2
. Gelfoam
, . (1)

Table 1. Angiographic findings of YES, PVA and Gelfoam group after embolization

	YES group (n=4)	PVA group (n=4)	Gelfoam (n=3)
Partial embolization	4*	2	0
Complete embolization	0	2	3
Recanalizaion after 8weeks	0	0	3

* number of cases

2.Laser flowmetry :

Perfusion Units(PU)

, PU 가 YES, PVA, Gelfoam
 730, 791, 544 8 PU 246, 117, 405 YES
 PVA . (2)

Table 2. Perfusion units (PU) of each embolic materials, YES, PVA, and Gelfoam. The perfusion units were measured performed by Laser doppler flowmetry and digitized

	YES	PVA	Gelfoam	Control
No. of animals	4	4	3	3
PU at pre-embolization	730.0±26.4	791.0±81.2	544.4±48.0	562.6±36.6
PU at 8 weeks of embolization	246.2±15.9*	117.5±17.9*	405.9±40.2	542.6±26.1

* : p<0.05 comparison with pre-embolization

3. MRI , CT

CT cortical rim sign YES
 , PVA Gelfoam 2 , 1 . (3)
 CT MRI , CT YES
 2 YES
 . PVA Gelfoam
 . MRI
 T2 YES
 . CT ,
 . (3) (4,5)

Table 3. CT findings of YES, PVA and Gelfoam group.

Findings	YES group (n=4)	PVA group (n=4)	Gelfoam group (n=3)
Cortical rim sign	4*	2	1
Conspicuity of embolic material	4	0	0

* number of cases

Fig 3-a

Fig 3-b

Fig. 3. Pre contrast CT images at 2 weeks after embolization:

- (c) Partially occluded Rt. renal artery of YES group shows cortical rim sign.
- (d) Nearly complete obstructed Rt. renal artery of PVA group shows cortical rim sign

Fig 4-a

Fig 4-b

Fig. 4(a,b). YES group: Pre-contrast CT image of embolized Rt. kidney 2 weeks after embolization shows high attenuation areas at corticomedullary junction(white arrow) which may suggest YES particle.

Fig. 5-a.

Fig 5-b.

Fig. 5. CT and MRI image of YES group at 2 weeks after embolization.

- (a) YES particles(white arrow) are readily visible on pre-contrast CT.
- (b) YES particle is not definite on MRI T2 weighted image alone. Differentiation of YES particle(white arrow) from other structures, such as signal void of vascular structure, is impossible.

4.

YES

, PVA

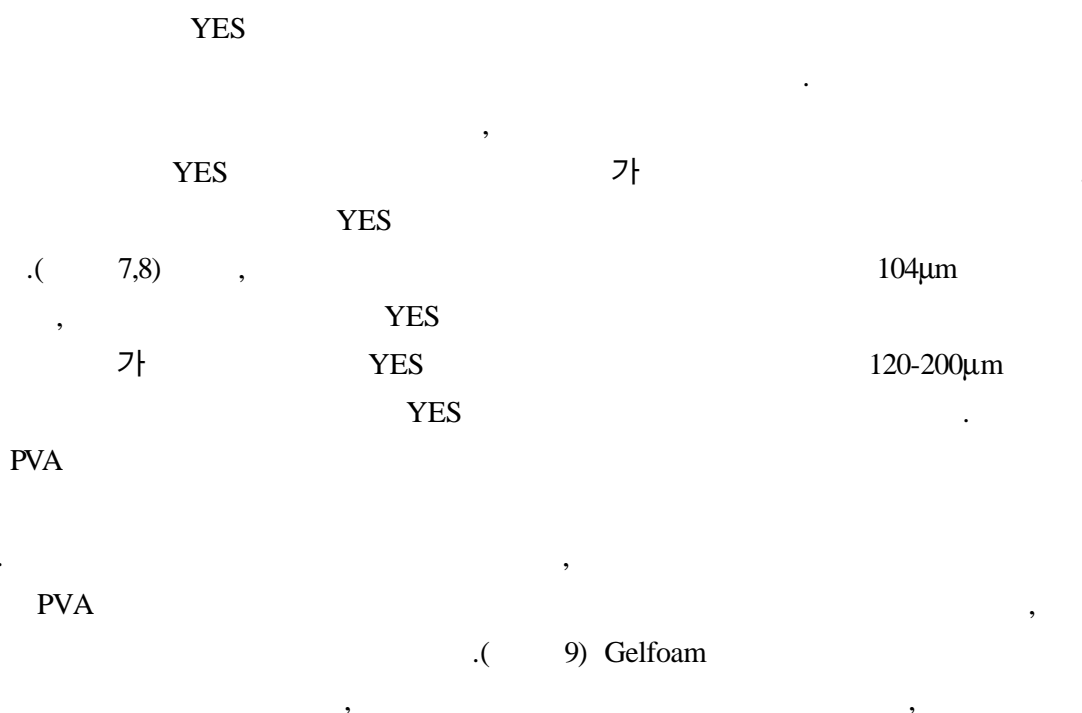
Gelfoam

., (6)

Fig 6-a

Fig 6-b

Fig. 6. (a)Histopathologic findings of embolized kidneys with YES: Gross specimens of both embolized and non-embolized kidneys on 8 weeks after embolization reveal distinct differences in viability between the totally necrotic small yellowish and tan appearance of embolized kidney and congested but relatively normal kidney. (b)Histopathologic findings of embolized kidneys with PVA: Gross specimens of embolized kidney on 8 weeks after embolization shows markedly thickened perirenal fat with inflammatory change and yellowish appearance of embolized kidney as compared with normal kidney.



가

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,

Gelfoam

Gelfoam

.(10)

Fig. 7. Sections obtained 8 weeks after embolization with 150-250 μ m YES: Several YES particles are seen in vascular lumen without aggregation or adhesion (hematoxyline-eosin, original magnification x100).

Fig. 8. Microphotograph of embolized vessel, after 8weeks with YES embolization. The occluded vessels and surrounding parenchyma were very mildly infiltrated by multinucleated giant cells, eosinophils, lymphocytes and few neutrophils (hematoxyline-eosin, original magnification x200).

Fig 9-a

Fig 9-b

Fig. 9. Microphotograph of embolized nidus, after 8weeks of embolization. (a). Organizing mass formation of PVA particles with the occluded large vessels at renal hilum are seen. Near total coagulation necrosis, calcifications and infiltration of inflammatory cells are seen in the renal parenchyma (hematoxyline-eosin, original magnification x100). (b) Another section (hematoxyline-eosin, original magnification x200) shows local capillary recanalization and degenerated vascular wall.

Fig. 10. Sections obtained 8 weeks after embolization with Gelfoam: Degeneration change due to ischemic change of vessel wall and coagulation necrosis of renal parenchyma is seen. Gelfoam particles are not seen in vessel lumen (hematoxyline-eosin, original magnification x40).

IV.

YES 4 12 가
. 8 가 8 , 6
24 , 1 14 7
. 24 , 가
, YES
. CT/MRI ,
가
가
PVA 4 가
8 , Gelfoam 5 2
가 7 가 , 3 가 .
가 , 가 , PVA, oxycel, Bucrylate, Wire coil,
Cyanoacrylate, Gelfoam, .
, Gelfoam, microfibrillar collagen) (silicon spheres, PVA, dextran
microspheres)
, 가
. 11
Gelfoam . 가
. 10
Gelfoam Light Prentice 가 1945
1964 Speakman
Gelfoam . Gelfoam
. Gelfoam

21-23 , 30-35
 Carmignani 120 Gelfoam 21
 . Reuter
 Gelfoam Jander
 Gelfoam 4
 . Gelfoam
 , Jander Gelfoam
 가
 . Gelfoam
 40-60 μm
 가 sheet
 Gelfoam 가 1mm , 8
 CT/MRI
 YES PVA
 . Laser flowmetry Gelfoam
 YES PVA 가
 PVA
 , 가
 . PVA 가
 PVA polyhedral
 , 가
 network .¹¹
 , 150 μm 가 PVA
 . PVA 가
 . PVA
 , 가 PVA

YES
 YES suspension
 , YES
 Quisling¹¹
 PVA 가 YES PVA YES 18mg, PVA
 11mg 가
 YES
 YES
 PVA
 CT 가
 가 CT
 'cortical rim sign'
 가 YES
 PVA Gelfoam
 PVA Gelfoam
 가 2 CT
 cortical rim sign YES PVA
 YES
 CT YES
 2 CT
 CT
 CT

YES
 . , 2
 가 CT YES YES
 . 8 CT
 MRI , ,
 T1, T2 , 가 ,
 MRI .
 0.3 Tesla MRI T2 YES
 , MRI
 CT YES
 MRI 1.5T
 가
 YES
 Gelfoam PVA
 YES 가 가
 YES
 , PVA Gelfoam ,
 16
 PVA YES PVA Gelfoam
 , YES
 가
 YES
 가
 PVA

Embosphere (Guerbet Biomedical; Louvres, France)¹⁷ 가 . Embosphere
 , , , trisacryl . Embospheres
 가 가 , 가
 . PVA . YES
 YES 가가 .
 YES YES
 , 가 가 가
 , YES 120-200 μ m
 , 가 104 μ m 가 YES
 , 가 , YES
 가 가
 가 Embosphere 가
 가 YES
 . YES
 가 ,
 PVA Gelfoam
 PVA 가 ,

V.

YES

Gelfoam PVA
CT MRI

3kg

15

CT MRI

8

YES

CT

YES

가

가

YES

Gelfoam

PVA

YES

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Abstract

A comparative study on transcatheter renal arterial embolization in rabbits with new embolic material (YES, Yonsei embolic substance), Polyvinyl alcohol and Gelfoam particles

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(Directed by Professor Hyung Sik Yoo)

Embolization is an accepted form of endovascular therapy such as tumor embolization or vascular malformation treatment. Variable embolic materials have been developed and have been used clinically. However, it is difficult to select an ideal embolic material. New embolic material YES (Bokwang, Gumi, Korea) is a microsphere that can be used easily. In the unique production process, Pt. particle and TiO₂ are mixed with PVA, they are of uniform size and accurately calibrated in variable size (30 – 1000 μm). Imaging characteristics and pathologic features of new embolic material (YES) were compared with PVA and Gelfoam particles in a rabbit with Rt. renal embolization model. Transcatheter renal arterial embolization was performed: 4 were embolized with YES, 4 with PVA, 3 with Gelfoam particles and 3 control groups. Pre and post-embolization angiography at five minutes and 8 weeks after embolization were performed. CT and MRI imaging were done at 1 day after embolization, 2 weeks and 8 weeks after embolization. All rabbits were sacrificed at 8 weeks after embolization for pathologic evaluation. On angiography, YES group and PVA group showed no evidence of recanalization after 8 weeks of embolization. Gelfoam group showed decrease of perfusion defect areas and partial recanalization after 8 weeks of embolization. Pre-contrast CT image showed high attenuation areas which might suggest YES particles at corticomedullary junction 2 weeks after embolization. In contrast, no evidence of visible particles in PVA and Gelfoam groups. Embolized kidney with YES revealed small, tan appearance that easily separated between renal capsule and perirenal fat. Markedly thickened perirenal fat and adhesion to renal capsule were seen at PVA and Gelfoam group. The YES group obstructed arcuate artery level without deformation and showing minimal vascular and perivascular inflammatory reaction. PVA group showed proximal interlobar artery, renal hilar arterial obstruction and moderate perivascular inflammatory reactions with degenerated vascular wall. Organized PVA particles with the occluded large vessels at renal hilum and local capillary recanalization were also seen. Gelfoam group obstructed renal hilar artery with severe degenerated vessel wall and perivascular

inflammatory reaction. No evidence of residual intact gelfoam particles was seen. The spherical YES particles were easy to use, they reached distal sites with filling of vascular lumen and produced a homogeneous and permanent occlusion without specific inflammatory changes. The good results of this experimental study led to a clinical trial of YES.

Key Words: Kidney, interventional procedure, angiography, Embolism