Glial fibrillary acidic protein (GFAP)

Glial fibrillary acidic protein (GFAP) is a main structural protein of astrocytes (astroglia) of the central nervous system (brain and spinal cord), and it is also found in non-myelinating Schwann cells of the peripheral nervous system. It sustains the cell shape and participates in the regulation of processes related to cell proliferation, synaptic plasticity, as well as the function of the blood brain barrier.

Biochemistry of GFAP

GFAP belongs to a group of intermediate filament III proteins. To date, ten isoforms of GFAP have been described. However, it is only the predominant isoform (Isoform 1, or GFAP-α) that has been shown to have clinical significance (1).

GFAP is a fibrillar protein of approximately 50 kDa. The formation of filaments includes the lateral dimerization of GFAP and head-to-tail polymerization of the dimers that are formed. The protein is highly conserved in different species and it is very similar to some other proteins that also participate in the formation of intermediate filaments, i.e. vimentin, desmin, peripherin and alpha-internexin.

GFAP as a marker in diagnostics

GFAP is a marker of glial cell injury. In circumstances where the glial cells are damaged, GFAP is released from cells and then appears in the blood. GFAP can be detected in blood samples shortly after the damage (2,3).

Marker of traumatic brain injury (TBI). Emerging evidence has shown that GFAP could be used as a TBI biomarker. It was shown that in the case of mild and moderate TBI, GFAP levels demonstrate a marked increase eight hours after the trauma (3). In addition, the concentration of GFAP has also been suggested to predict the outcome of the injury (4). Furthermore, one test that measures GFAP (and UCH-L1) has been approved by the Food and Drug Administration for evaluating mild TBI (5).

Differentiation between a hemorrhagic and an ischemic stroke. An increasing number of studies have indicated that GFAP might be a useful biomarker for the differentiation between a hemorrhagic and an ischemic stroke. Both can have severe consequences, but since these two forms of strokes have different mechanisms, they require opposite strategies of treatment. Therefore, it is important to find tools that help in terms of differentiating between the two strokes as early as possible. Studies have shown that GFAP increases in the case of a hemorrhagic stroke within two hours after stroke onset, with peaking taking place between 6 and 12 hours after stroke onset. Instead, in the case of an ischemic stroke, the GFAP levels in blood increase at a later time point (2,6).

Reagents for detecting GFAP

We provide several monoclonal antibodies (MAbs) specific to GFAP. In addition, we offer recombinant GFAP antigen that can be used as a standard or calibrator in immunoassays.

CLINICAL UTILITY

- **Traumatic brain injury (TBI)**

MONOCLONAL ANTIBODIES SPECIFIC TO GFAP

Hytest offers several well-characterized monoclonal antibodies (MAbs) that are specific to GFAP and which may be used for the quantification of GFAP in serum, plasma or cerebrospinal fluid.

Sandwich immunoassays for GFAP detection

For the detection of GFAP in citrate or heparin plasma samples or in serum samples using a sandwich immunoassay, we recommend three different MAb combinations (see Table 1). These pairs showed no cross-reactivity to vimentin, desmin and peripherin. Calibration curves using the GFAP83cc-GFAP81cc (A) and GFAP83cc-GFAP98cc (B) prototype assays are shown in Figure 1.

Table 1.

Recommended capture-detection pairs. Data is based on the results that were obtained using a sandwich chemiluminescence immunoassay (CLIA). LoD= limit of detection.

Capture MAb	Detection MAb	LoD (pg/ml)
GFAP83cc	GFAP81cc	4.8
GFAP94cc	GFAP98cc	15.3
GFAP15cc	GFAP81cc	13.3

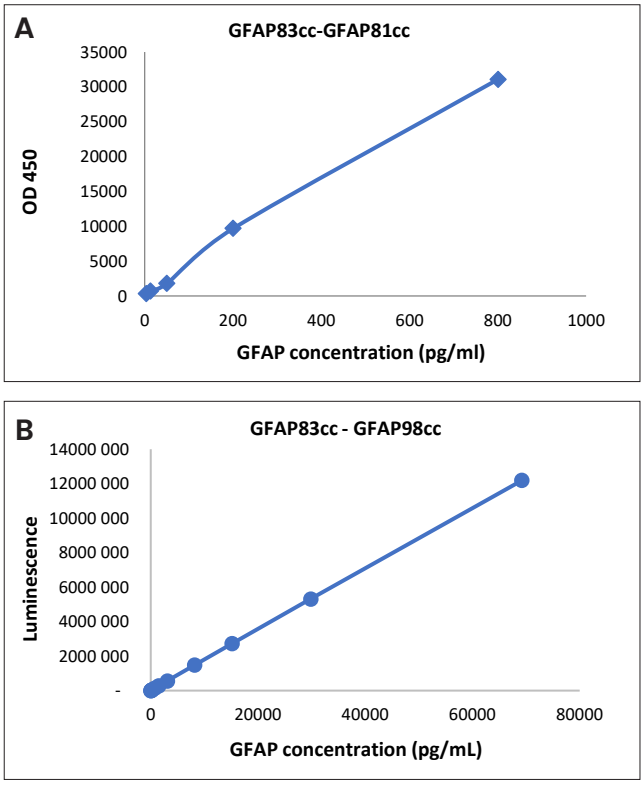

Figure 1.
Calibration curve for
A) GFAP83cc-GFAP81cc (capture-detection) pair using native GFAP as the antigen
B) GFAP83cc-GFAP98cc (capture-detection) pair using recombinant GFAP as the antigen.

Correlation of the serum GFAP concentrations

GFAP concentration in human serum samples was measured by the commercially available assay, Simoa® GFAP (Quanterix) and also with Hytest's prototype assay using pair GFAP83cc-GFAP98cc. GFAP levels were measured in 34 serum samples, with concentrations ranging from 46 - 33 074 pg/ml (as shown in Fig. 2A). The correlation curve was also drawn for the lower concentration ranging from 46 -1000 pg/mg in 18 serum samples (Fig. 2B). As shown in the Figure 2, we observed a strong correlation between Hytest's prototype assay with the reference assay.

Detection of GFAP in clinical samples

Figure 3 illustrates the detection of GFAP in plasma samples that were obtained from patients with either a hemorrhagic (N=5) or an ischemic (N=5) stroke using the GFAP83cc–GFAP81cc assay. All of the samples were taken within the first 12 hours following the injury. The prototype assay only detected GFAP in the plasma samples from patients who suffered a hemorrhagic stroke. This is in line with the results from other studies and suggests that GFAP can be used for discriminating these two types of strokes. In ischemic strokes, the level of GFAP should only increase at a later time point.

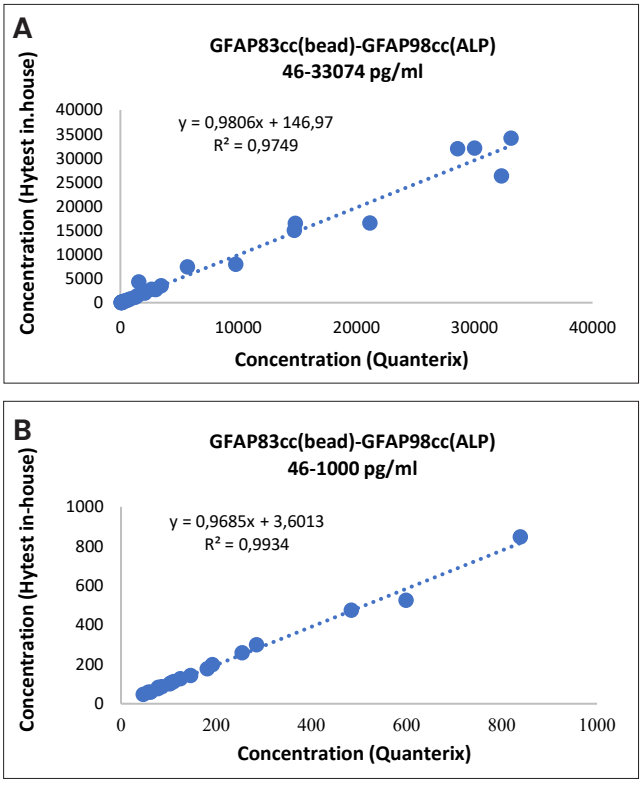

Figure 2.
Correlation between measurement results of
A) GFAP in 34 serum samples (concentrations ranging from 46-33074 pg/ml)
B) GFAP in 18 serum samples (concentrations ranging from 46-1000 pg/ml) using the GFAP83cc-GFAP98cc prototype assay, with the Simoa® GFAP (Quanterix)

MAbs suitable for immunohistochemistry

The MAbs GFAP15cc, GFAP81cc and GFAP83cc are applicable in immunohistochemistry. An example of staining GFAP in glial cells by using GFAP81cc is shown in Figure 4.

RECOMBINANT GFAP

HyTest recombinant GFAP is suitable to be used as a standard or calibrator in immunoassays. The antigen consists of amino acids 60-383 of human GFAP and it is expressed in *E. coli*. Purity of the antigen is over 90%. SDS-PAGE of recombinant GFAP reveals that it migrates as one band with apparent molecular weight of 34 kDa (see Figure 5).

It should be noted that GFAP is a fibrillar protein and prone to polymerization. Also, the recombinant GFAP tends to form dimers and thus the purified protein preparation likely always contains some amount of dimeric GFAP. Long-term incubation at positive temperatures increases percentage of dimeric form, and can, eventually, lead to further aggregation.

Recombinant GFAP tolerates freeze-thaw cycles

We tested the immunochemical stability of recombinant GFAP after repeated freeze-thaw cycles. The immunoreactivity, as measured using GFAP83cc–GFAP81cc prototype assay, did not change significantly after the protein has been subjected to ten freeze-thaw cycles (see Figure 6).

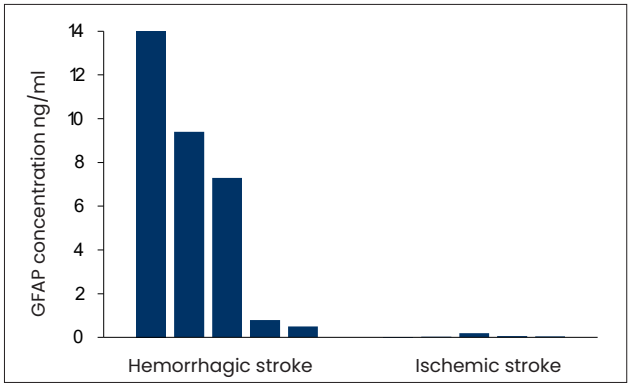

Figure 3.
GFAP was measured in plasma samples from hemorrhagic and ischemic stroke patients by using the GFAP83cc–GFAP81cc prototype assay.

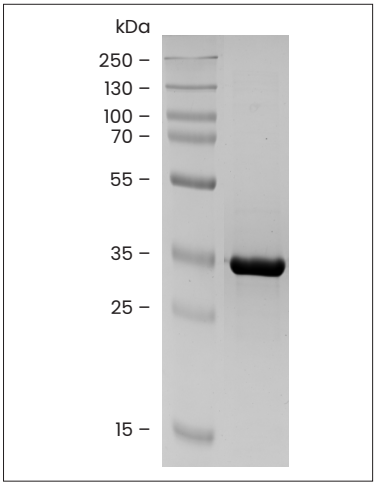

Figure 5.
SDS-PAGE of recombinant GFAP fragment under reducing conditions in a gradient gel (10-20%). 2 µg of purified protein was loaded on the gel.

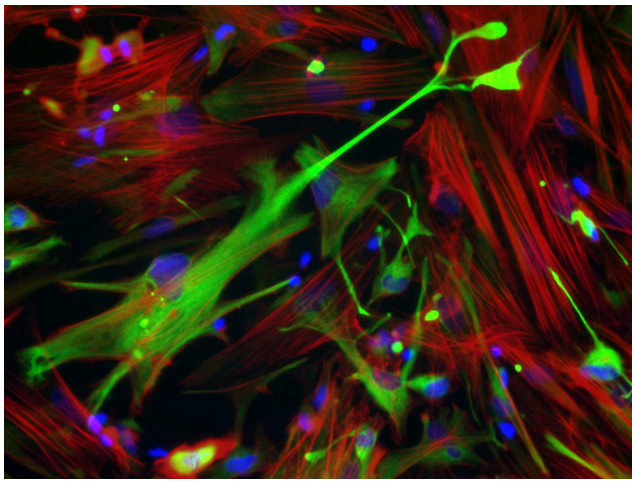

Figure 4.
Staining of GFAP in cultivated glial cells. Primary antibody: GFAP81cc. Secondary antibody: Anti-mouse polyclonal antibodies conjugated with Alexa-488 (green).

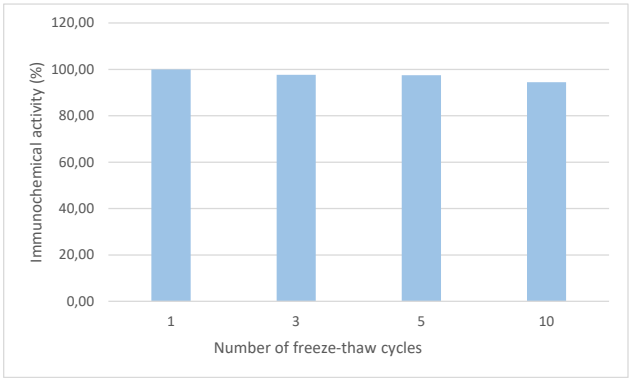

Figure 6.
Freeze-thaw stability of recombinant GFAP. Aliquot of recombinant GFAP was subjected to ten freeze-thaw cycles. Immunoreactivity after first, third, fifth and tenth cycles was measured using a sandwich immunoassay (GFAP83cc–GFAP81cc).

REFERENCES

1. **Middeldorp, J. & Hol, E. M.** GFAP in health and disease. Progress in Neurobiology 93, 421–443 (2011).
2. **Foerch, C. et al.** Diagnostic accuracy of plasma glial fibrillary acidic protein for differentiating intracerebral hemorrhage and cerebral ischemia in patients with symptoms of acute stroke. Clinical Chemistry 58, 237–245 (2012).
3. **Papa, L. et al.** Time course and diagnostic accuracy of glial and neuronal blood biomarkers GFAP and UCH-L1 in a large cohort of trauma patients with and without mild traumatic brain injury. JAMA Neurology 73, 551 (2016).
4. **Vos, P. E. et al.** GFAP and S100B are biomarkers of traumatic brain injury: An observational cohort study. Neurology 75, 1786–1793 (2010).
5. **U.S. Food & Drug Administration.** FDA authorizes marketing of first blood test to aid in the evaluation of concussion in adults. FDA (2018). At <http://www.fda.gov/news-events/press-announcements/fda-authorizes-marketing-first-blood-test-aid-evaluation-concussion-adults>
6. **Herrmann, M. et al.** Release of glial tissue-specific proteins after acute stroke: A comparative analysis of serum concentrations of protein S-100B and glial fibrillary acidic protein. Stroke 31, 2670–2677 (2000).

ORDERING INFORMATION

MONOCLONAL ANTIBODIES

Product name	Cat. #	MAb	Subclass	Remarks
Glial fibrillary acidic protein (GFAP)	4G25	GFAP15cc	IgG1	*In vitro*, EIA, WB, IHC
		GFAP81cc	IgG1	*In vitro*, EIA, WB, IHC
		GFAP83cc	IgG1	*In vitro*, EIA, WB, IHC
		GFAP94cc	IgG1	*In vitro*, EIA, WB
		GFAP98cc	IgG1	*In vitro*, EIA, WB

ANTIGENS

Product name	Cat. #	Purity	Source
Glial fibrillary acidic protein (GFAP), human, recombinant	8G47	>90%	Recombinant
Glial fibrillary acidic protein (GFAP), human, recombinant	8G45	>90%	Recombinant

HYTEST LTD
Intelligate 1, 6th floor, Joukahaisenkatu 6 • FI-20520 Turku, FINLAND
Tel. +358 2 512 0900 • E-mail: hytest@hytest.fi • **HYTEST.FI**