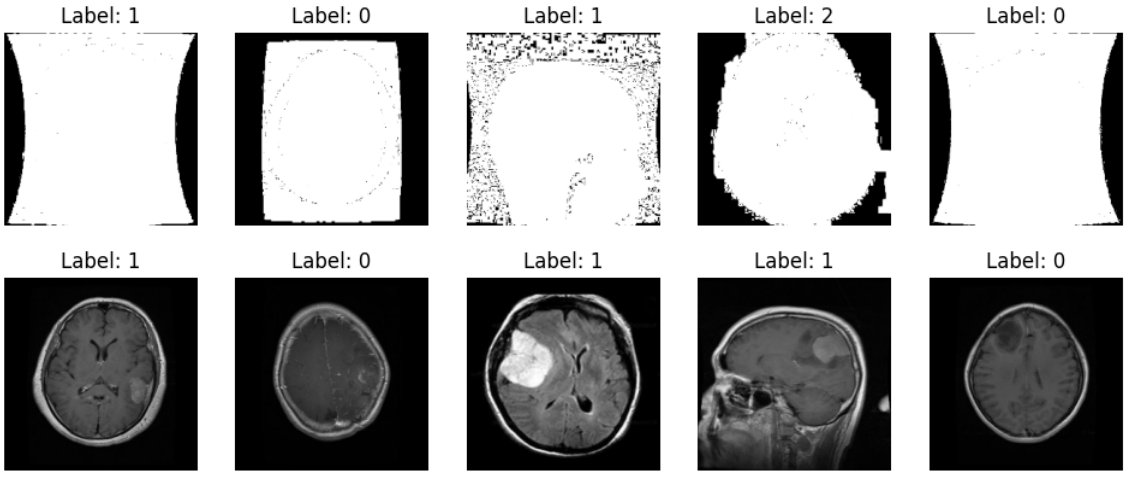
In [9]:
```
from src.data_preprocessing.load_data import load_data
from src.data_preprocessing.data_augmentation import augment_data
from src.data_preprocessing.basic_preprocessing import preprocess_data
from src.data_preprocessing.displayer import display_images
from src.training.training import create_resnet50_model, create_mobilenetv2_model, create_vgg16_model, plot_training_history, train_model
from src.training.optimize_dataset import optimize_dataset
from src.training.save_model import save_model_and_history
from src.evaluation.evaluation import evaluate_model
```

In [10]:
```
SAVE_BASE_DIR = './saved'

IMAGE_COLUMN = 224
IMAGE_ROW = 224
IMAGE_SIZE = (IMAGE_COLUMN, IMAGE_ROW)
INPUT_SIZE = (IMAGE_COLUMN, IMAGE_ROW, 3)
NUM_CLASSES = 4

TRAINING_DIR = './data/raw/Training/'
TESTING_DIR = './data/raw/Testing/'
BATCH_SIZE = 32
EPOCHS = 10
```

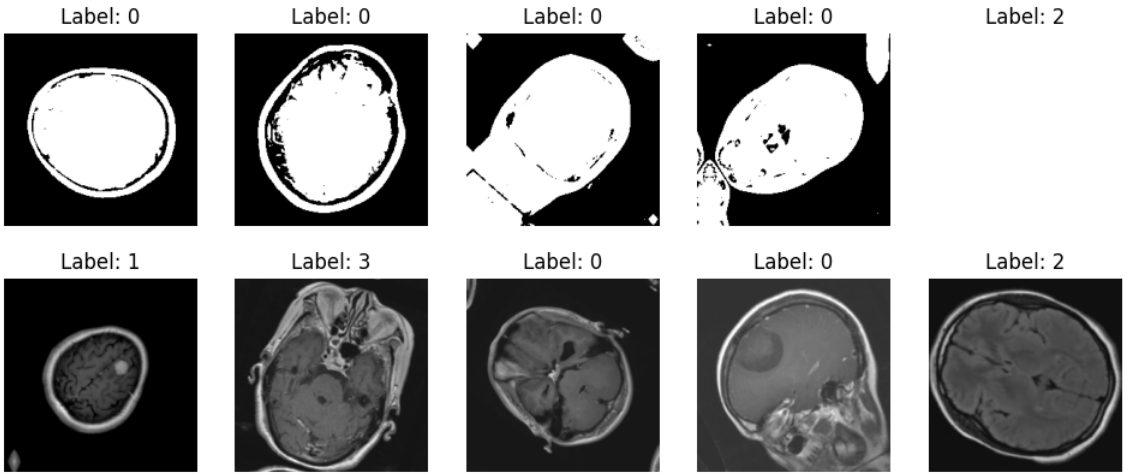
In [11]:
```
trainset, validset, testset = load_data(
    TRAINING_DIR,
    training_dir=TRAINING_DIR,
    testing_dir=TESTING_DIR,
    batch_size=BATCH_SIZE,
    img_size=IMAGE_SIZE,
    color_mode='rgb'
)

print(trainset.class_names)
print(validset.class_names)
print(testset.class_names)
class_names = testset.class_names

display_images(trainset, num_images=5, color_mode='jet', normalize=False)
display_images(trainset, num_images=5, color_mode='jet', normalize=True)
```

```
Found 5712 files belonging to 4 classes.
Using 4570 files for training.
Found 5712 files belonging to 4 classes.
Using 1142 files for validation.
Found 1311 files belonging to 4 classes.
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..249.16835].
['glioma', 'meningioma', 'notumor', 'pituitary']
['glioma', 'meningioma', 'notumor', 'pituitary']
['glioma', 'meningioma', 'notumor', 'pituitary']
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..238.05577].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..249.0].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..226.45088].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..237.21411].
```



In [12]:
```
augmented_trainset = augment_data(trainset)

display_images(augmented_trainset, num_images=5, color_mode='jet', normalize=False)
display_images(augmented_trainset, num_images=5, color_mode='jet', normalize=True)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..214.1822].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..171.06606].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..207.29034].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [0.0..210.88033].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [50.357517..255.0].
```

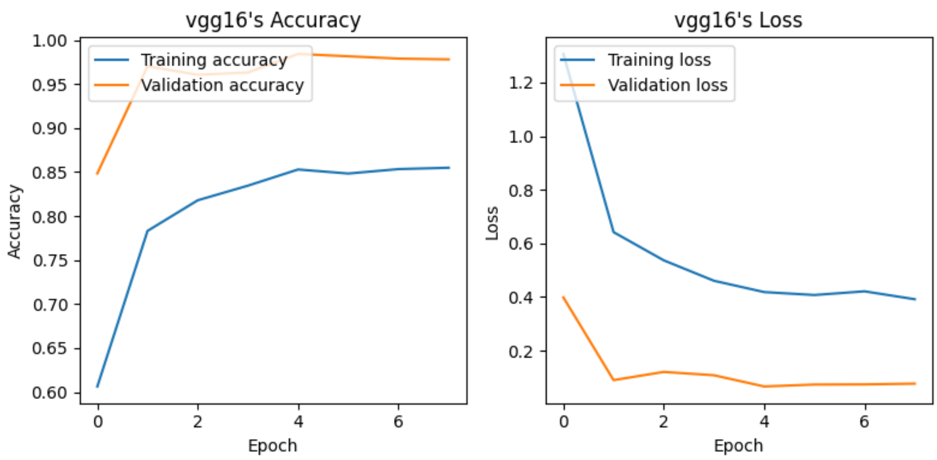


In [13]:
```
preprocessed_trainset = preprocess_data(augmented_trainset, img_size=IMAGE_SIZE, model_type='vgg16')
preprocessed_validset = preprocess_data(validset, img_size=IMAGE_SIZE, model_type='vgg16')
preprocessed_testset = preprocess_data(testset, img_size=IMAGE_SIZE, model_type='vgg16')

display_images(preprocessed_trainset, num_images=5, color_mode='jet')

optimized_trainset = optimize_dataset(preprocessed_trainset, batch_size=BATCH_SIZE, prefetch=True, shuffle=True)
optimized_validset = optimize_dataset(preprocessed_validset, batch_size=BATCH_SIZE, prefetch=True)
optimized_testset = optimize_dataset(preprocessed_testset, batch_size=BATCH_SIZE, prefetch=True)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..125.995445].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..129.94101].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..114.595024].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-113.086044..151.061].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-95.62641..151.061].
```

In [14]:
```
vgg16_model = create_vgg16_model(input_shape=INPUT_SIZE, num_classes=NUM_CLASSES)

vgg16_history, vgg16_model = train_model(
    vgg16_model,
    optimized_trainset,
    optimized_validset,
    batch_size=BATCH_SIZE,
    epochs=EPOCHS,
)

plot_training_history(vgg16_history, model_name='vgg16',
                      save_path=f'{SAVE_BASE_DIR}/vgg16/plot.png')

evaluate_model(vgg16_model, optimized_testset, class_names=class_names)

save_model_and_history(vgg16_model, vgg16_history,
                       model_filename=f"{SAVE_BASE_DIR}/vgg16/model.keras",
                       history_filename=f"{SAVE_BASE_DIR}/vgg16/history.json")
```

```
Epoch 1/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 357s 2s/step - accuracy: 0.6063 - loss: 1.3061 - val_accuracy: 0.8485 - val_loss: 0.3985 - learning_rate: 0.0010
Epoch 2/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 421s 3s/step - accuracy: 0.7832 - loss: 0.6419 - val_accuracy: 0.9702 - val_loss: 0.0903 - learning_rate: 0.0010
Epoch 3/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 605s 4s/step - accuracy: 0.8179 - loss: 0.5368 - val_accuracy: 0.9606 - val_loss: 0.1209 - learning_rate: 0.0010
Epoch 4/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 0s 2s/step - accuracy: 0.8334 - loss: 0.4712
Epoch 4: ReduceLROnPlateau reducing learning rate to 0.00010000000474974513.
143/143 ━━━━━━━━━━━━━━━━━━━━ 486s 3s/step - accuracy: 0.8346 - loss: 0.4607 - val_accuracy: 0.9632 - val_loss: 0.1084 - learning_rate: 0.0010
Epoch 5/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 606s 4s/step - accuracy: 0.8530 - loss: 0.4185 - val_accuracy: 0.9842 - val_loss: 0.0667 - learning_rate: 1.0000e-04
Epoch 6/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 472s 3s/step - accuracy: 0.8484 - loss: 0.4076 - val_accuracy: 0.9816 - val_loss: 0.0738 - learning_rate: 1.0000e-04
Epoch 7/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 0s 3s/step - accuracy: 0.8483 - loss: 0.4355
Epoch 7: ReduceLROnPlateau reducing learning rate to 1.0000000474974514e-05.
143/143 ━━━━━━━━━━━━━━━━━━━━ 535s 3s/step - accuracy: 0.8534 - loss: 0.4213 - val_accuracy: 0.9790 - val_loss: 0.0743 - learning_rate: 1.0000e-04
Epoch 8/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 516s 3s/step - accuracy: 0.8549 - loss: 0.3919 - val_accuracy: 0.9781 - val_loss: 0.0772 - learning_rate: 1.0000e-05
Plot saved to ./saved/vgg16/plot.png
```



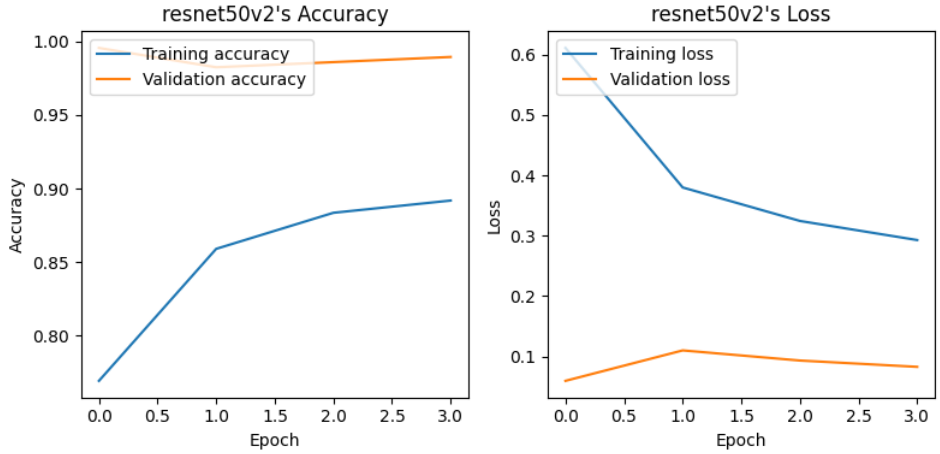

```
41/41 ━━━━━━━━━━━━━━━━━━━━ 123s 3s/step - accuracy: 0.8024 - loss: 0.6524
Test loss: 0.6524
Test accuracy: 0.8024
1/1 ━━━━━━━━━━━━━━━━━━━━ 4s 4s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 4s 4s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 4s 4s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 3s 3s/step

=== Classification Report ===
              precision    recall  f1-score   support

      glioma       0.84      0.76      0.80       300
  meningioma       0.67      0.58      0.62       306
     notumor       0.95      0.87      0.91       405
   pituitary       0.73      0.98      0.83       300

    accuracy                           0.80      1311
   macro avg       0.80      0.80      0.79      1311
weighted avg       0.81      0.80      0.80      1311

Model saved to ./saved/vgg16/model.keras
Training history saved to ./saved/vgg16/history.json
```

In [15]:
```
preprocessed_trainset = preprocess_data(augmented_trainset, img_size=IMAGE_SIZE, model_type='resnet50v2')
preprocessed_validset = preprocess_data(validset, img_size=IMAGE_SIZE, model_type='resnet50v2')
preprocessed_testset = preprocess_data(testset, img_size=IMAGE_SIZE, model_type='resnet50v2')

display_images(preprocessed_trainset, num_images=5, color_mode='jet')

optimized_trainset = optimize_dataset(preprocessed_trainset, batch_size=BATCH_SIZE, prefetch=True, shuffle=True)
optimized_validset = optimize_dataset(preprocessed_validset, batch_size=BATCH_SIZE, prefetch=True)
optimized_testset = optimize_dataset(preprocessed_testset, batch_size=BATCH_SIZE, prefetch=True)
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..115.69604].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..94.554726].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-110.911804..151.061].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-123.68..114.653786].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-94.54948..151.061].
```

In [16]:
```
resnet50_model = create_resnet50_model(input_shape=INPUT_SIZE, num_classes=NUM_CLASSES)

resnet50_history, resnet50_model = train_model(
    resnet50_model,
    optimized_trainset,
    optimized_validset,
    batch_size=BATCH_SIZE,
    epochs=EPOCHS
)

plot_training_history(resnet50_history, model_name='resnet50v2',
                      save_path=f'{SAVE_BASE_DIR}/resnet50v2/plot.png')

evaluate_model(resnet50_model, optimized_testset, class_names=class_names)

save_model_and_history(resnet50_model, resnet50_history,
                       model_filename=f"{SAVE_BASE_DIR}/resnet50v2/model.keras",
                       history_filename=f"{SAVE_BASE_DIR}/resnet50v2/history.json")
```

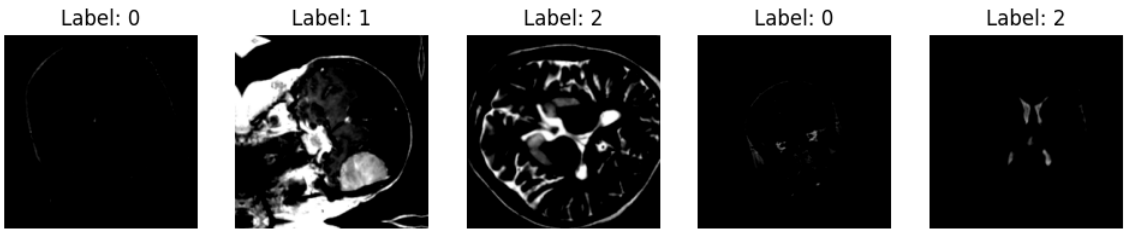
```
Epoch 1/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 299s 1s/step - accuracy: 0.7694 - loss: 0.6108 - val_accuracy: 0.9956 - val_loss: 0.0598 - learning_rate: 0.0010
Epoch 2/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 273s 1s/step - accuracy: 0.8591 - loss: 0.3799 - val_accuracy: 0.9825 - val_loss: 0.1102 - learning_rate: 0.0010
Epoch 3/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.8817 - loss: 0.3269
Epoch 3: ReduceLROnPlateau reducing learning rate to 0.00010000000474974513.
143/143 ━━━━━━━━━━━━━━━━━━━━ 275s 1s/step - accuracy: 0.8836 - loss: 0.3245 - val_accuracy: 0.9860 - val_loss: 0.0935 - learning_rate: 0.0010
Epoch 4/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 282s 1s/step - accuracy: 0.8919 - loss: 0.2929 - val_accuracy: 0.9895 - val_loss: 0.0830 - learning_rate: 1.0000e-04
Plot saved to ./saved/resnet50v2/plot.png
```



```
41/41 ━━━━━━━━━━━━━━━━━━━━ 46s 1s/step - accuracy: 0.7727 - loss: 0.5862
Test loss: 0.5862
Test accuracy: 0.7727
1/1 ━━━━━━━━━━━━━━━━━━━━ 5s 5s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 5s 5s/step

=== Classification Report ===
              precision    recall  f1-score   support

      glioma       0.84      0.76      0.80       300
  meningioma       0.75      0.37      0.49       306
     notumor       0.92      0.92      0.92       405
   pituitary       0.62      1.00      0.76       300

    accuracy                           0.77      1311
   macro avg       0.78      0.76      0.74      1311
weighted avg       0.79      0.77      0.76      1311

Model saved to ./saved/resnet50v2/model.keras
Training history saved to ./saved/resnet50v2/history.json
```

In [17]:
```python
preprocessed_trainset = preprocess_data(augmented_trainset, img_size=IMAGE_SIZE, model_type='mobilenetv2')
preprocessed_validset = preprocess_data(validset, img_size=IMAGE_SIZE, model_type='mobilenetv2')
preprocessed_testset = preprocess_data(testset, img_size=IMAGE_SIZE, model_type='mobilenetv2')

display_images(preprocessed_trainset, num_images=5, color_mode='jet')

optimized_trainset = optimize_dataset(preprocessed_trainset, batch_size=BATCH_SIZE, prefetch=True, shuffle=True)
optimized_validset = optimize_dataset(preprocessed_validset, batch_size=BATCH_SIZE, prefetch=True)
optimized_testset = optimize_dataset(preprocessed_testset, batch_size=BATCH_SIZE, prefetch=True)
```

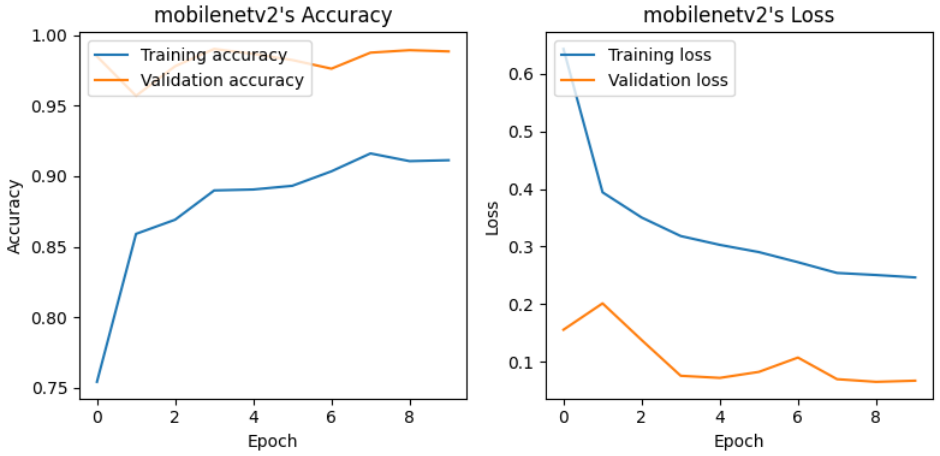
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-1.0..0.35400665].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-0.783746..1.0].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-0.9429736..1.0].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-1.0..0.6667644].
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-1.0..0.63659215].
```



In [18]:
```python
mobilenetv2_model = create_mobilenetv2_model(input_shape=INPUT_SIZE, num_classes=NUM_CLASSES)

mobilenetv2_history, mobilenetv2_model = train_model(
    mobilenetv2_model,
    optimized_trainset,
    optimized_validset,
    batch_size=BATCH_SIZE,
    epochs=EPOCHS
)

plot_training_history(mobilenetv2_history, model_name='mobilenetv2',
                      save_path=f'{SAVE_BASE_DIR}/mobilenetv2/plot.png')
```

```
evaluate_model(mobilenetv2_model, optimized_testset, class_names=class_names)

save_model_and_history(mobilenetv2_model, mobilenetv2_history,
                       model_filename=f"{SAVE_BASE_DIR}/mobilenetv2/model.keras",
                       history_filename=f"{SAVE_BASE_DIR}/mobilenetv2/history.json")
```

```
Epoch 1/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 143s 400ms/step - accuracy: 0.7540 - loss: 0.6425 - val_accuracy: 0.9851 - val_loss: 0.1561 - learning_rate: 0.0010
Epoch 2/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 133s 388ms/step - accuracy: 0.8591 - loss: 0.3941 - val_accuracy: 0.9571 - val_loss: 0.2017 - learning_rate: 0.0010
Epoch 3/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 133s 377ms/step - accuracy: 0.8691 - loss: 0.3505 - val_accuracy: 0.9781 - val_loss: 0.1382 - learning_rate: 0.0010
Epoch 4/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 145s 444ms/step - accuracy: 0.8899 - loss: 0.3183 - val_accuracy: 0.9904 - val_loss: 0.0763 - learning_rate: 0.0010
Epoch 5/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 2285s 16s/step - accuracy: 0.8906 - loss: 0.3031 - val_accuracy: 0.9869 - val_loss: 0.0726 - learning_rate: 0.0010
Epoch 6/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 55s 208ms/step - accuracy: 0.8932 - loss: 0.2906 - val_accuracy: 0.9825 - val_loss: 0.0830 - learning_rate: 0.0010
Epoch 7/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 0s 345ms/step - accuracy: 0.9098 - loss: 0.2681
Epoch 7: ReduceLROnPlateau reducing learning rate to 0.00010000000474974513.
143/143 ━━━━━━━━━━━━━━━━━━━━ 91s 432ms/step - accuracy: 0.9035 - loss: 0.2730 - val_accuracy: 0.9764 - val_loss: 0.1079 - learning_rate: 0.0010
Epoch 8/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 91s 410ms/step - accuracy: 0.9162 - loss: 0.2544 - val_accuracy: 0.9877 - val_loss: 0.0704 - learning_rate: 1.0000e-0
4
Epoch 9/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 91s 412ms/step - accuracy: 0.9107 - loss: 0.2509 - val_accuracy: 0.9895 - val_loss: 0.0658 - learning_rate: 1.0000e-0
4
Epoch 10/10
143/143 ━━━━━━━━━━━━━━━━━━━━ 89s 402ms/step - accuracy: 0.9114 - loss: 0.2467 - val_accuracy: 0.9886 - val_loss: 0.0678 - learning_rate: 1.0000e-0
4
Plot saved to ./saved/mobilenetv2/plot.png
```



```
41/41 ━━━━━━━━━━━━━━━━━━━━ 12s 291ms/step - accuracy: 0.8391 - loss: 0.4217
Test loss: 0.4217
Test accuracy: 0.8391
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 378ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 349ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 362ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 358ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 349ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 349ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 364ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 355ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 341ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 356ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 331ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 355ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 344ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 353ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 346ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 344ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 357ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 353ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 349ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 355ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 359ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 327ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 364ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 347ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 353ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 361ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 360ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 346ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 362ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 368ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 338ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 370ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 333ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 363ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 336ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 367ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 345ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 356ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 340ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step

=== Classification Report ===
              precision    recall  f1-score   support

      glioma       0.88      0.79      0.83       300
  meningioma       0.75      0.61      0.68       306
     notumor       0.93      0.94      0.93       405
   pituitary       0.77      0.99      0.87       300

    accuracy                           0.84      1311
   macro avg       0.83      0.83      0.83      1311
weighted avg       0.84      0.84      0.83      1311

Model saved to ./saved/mobilenetv2/model.keras
Training history saved to ./saved/mobilenetv2/history.json
```

In [22]:

```python
import os
import tensorflow as tf
import numpy as np
import keras
from src.data_preprocessing.basic_preprocessing import preprocess_data

import os
import tensorflow as tf

model = keras.models.load_model('./saved/resnet50v2/model.keras')

testing_dir = 'data/raw/Testing/'
first_images = {}

for class_name in os.listdir(testing_dir):
    class_path = os.path.join(testing_dir, class_name)

    if os.path.isdir(class_path):
        files = os.listdir(class_path)
        image_files = [f for f in files if f.lower().endswith(('.png', '.jpg', '.jpeg'))]

        if image_files:
            first_image_path = os.path.join(class_path, image_files[0])

            img = tf.io.read_file(first_image_path)
            img = tf.image.decode_image(img, channels=3)
            img = tf.cast(img, tf.float32)

            first_images[class_name] = img
            print(first_image_path)

class_names = list(first_images.keys())

for class_name, img_tensor in first_images.items():
    dataset = tf.data.Dataset.from_tensors((img_tensor, 0))
    preprocessed_dataset = preprocess_data(dataset, img_size=(224, 224), normalize=True, model_type='vgg16')
    for x, y in preprocessed_dataset:
        img_preprocessed = x

    img_batch = tf.expand_dims(img_preprocessed, axis=0)
```

```
    predictions = model.predict(img_batch)
    predicted_class_idx = np.argmax(predictions, axis=-1)[0]
    probability = predictions[0][predicted_class_idx]
    predicted_class_name = class_names[predicted_class_idx]

    print(f"True class: {class_name}")
    print(f"Predicted class index: {predicted_class_idx}")
    print(f"Predicted class name: {predicted_class_name}")
    print(f"Probability: {probability}\n")
```

```
data/raw/Testing/glioma\Te-glTr_0000.jpg
data/raw/Testing/meningioma\Te-meTr_0000.jpg
data/raw/Testing/notumor\Te-noTr_0000.jpg
data/raw/Testing/pituitary\Te-piTr_0000.jpg
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
True class: glioma
Predicted class index: 0
Predicted class name: glioma
Probability: 0.9658101797103882

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 101ms/step
True class: meningioma
Predicted class index: 1
Predicted class name: meningioma
Probability: 0.575107991695404

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 80ms/step
True class: notumor
Predicted class index: 1
Predicted class name: meningioma
Probability: 0.780962347984314

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 80ms/step
True class: pituitary
Predicted class index: 3
Predicted class name: pituitary
Probability: 0.9767659902572632
```