```python
In [51]:  import pandas as pd
          import numpy as np
          import matplotlib.pyplot as plt
          import seaborn as sns
          from sklearn.model_selection import train_test_split, cross_val_score
          from sklearn.preprocessing import StandardScaler
          from sklearn.linear_model import LinearRegression
          from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
          import pickle
```

```python
In [100… file_path = "final.csv"
         dataset = pd.read_csv(file_path)
```

```python
In [101… X = dataset[[ "catheter_bag_volume"]]
         y = dataset["time"]
```

```python
In [102… scaler = StandardScaler()
         X_scaled = scaler.fit_transform(X)
```

```python
In [103… X_train, X_temp, y_train, y_temp = train_test_split(X_scaled, y, test_size=0.3)  # 70% training
         X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.5)

         model = LinearRegression()
         model.fit(X_train, y_train)
```

Out[103…
```
▾ LinearRegression  ⓘ ?

LinearRegression()
```

```python
In [104… y_val_pred = model.predict(X_val)
```

```python
In [105… val_mse = mean_squared_error(y_val, y_val_pred)
         val_mae = mean_absolute_error(y_val, y_val_pred)
         val_r2 = r2_score(y_val, y_val_pred)

         print("\n✅ VALIDATION RESULTS:")
         print(f"Validation MSE: {val_mse}")
         print(f"Validation MAE: {val_mae}")
         print(f"Validation R²: {val_r2}")
```

```
✅ VALIDATION RESULTS:
Validation MSE: 1.877232199374567e-06
Validation MAE: 0.001141673933263042
Validation R²: 0.9999999999567163
```

```python
In [106… y_test_pred = model.predict(X_test)

         # 📌 Compute Test Metrics
         test_mse = mean_squared_error(y_test, y_test_pred)
         test_mae = mean_absolute_error(y_test, y_test_pred)
         test_r2 = r2_score(y_test, y_test_pred)

         print("\n✅ TEST RESULTS:")
         print(f"Test MSE: {test_mse}")
         print(f"Test MAE: {test_mae}")
         print(f"Test R²: {test_r2}")
```
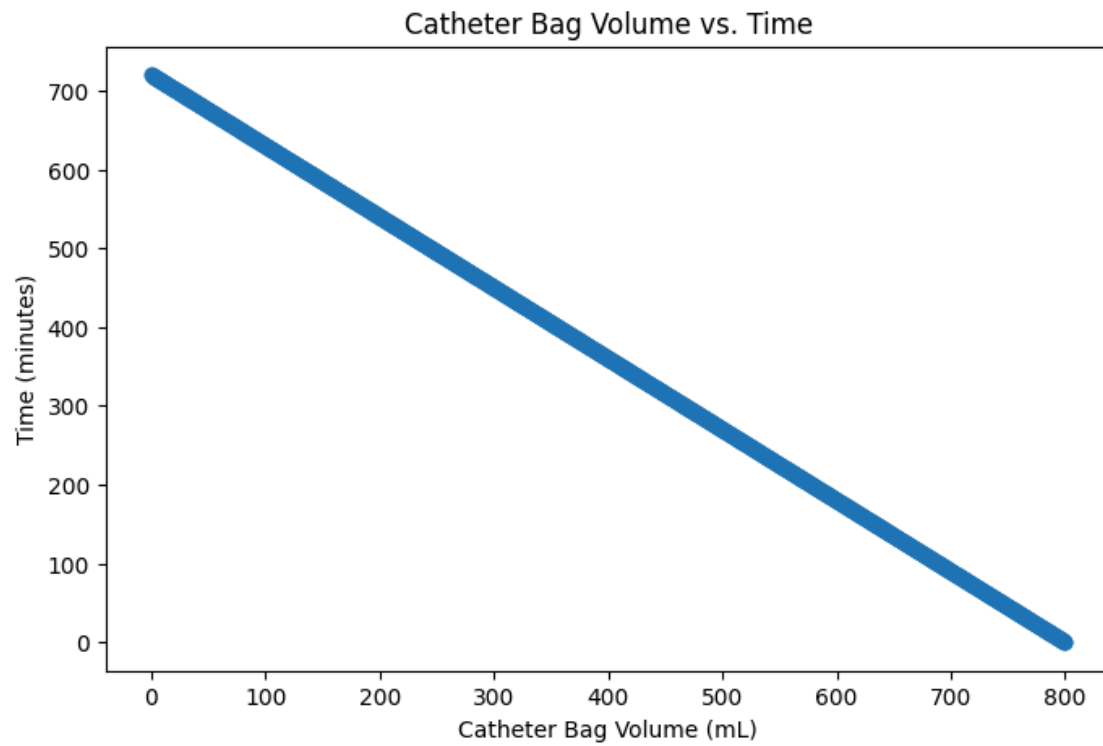
```
✅ TEST RESULTS:
Test MSE: 1.7946615405869362e-06
Test MAE: 0.0011162306262122966
Test R²: 0.9999999999571767
```

```python
In [107… with open("model_1.pkl", "wb") as file:
             pickle.dump(model, file)
         with open("scaler.pkl", "wb") as file:
             pickle.dump(scaler, file)
```

```python
In [108… import matplotlib.pyplot as plt

         plt.figure(figsize=(8,5))
         plt.scatter(dataset["catheter_bag_volume"], dataset["time"], alpha=0.5)
         plt.xlabel("Catheter Bag Volume (mL)")
```

```
plt.ylabel("Time (minutes)")
plt.title("Catheter Bag Volume vs. Time")
plt.show()
```

Catheter Bag Volume vs. Time

In [ ]: